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EFFECTIVE RANGE SURVEYS AS A FACTOR IN RANGE MANAGEMENT

By Elbert H. Reid, Assistant Range Examiner, and
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Table of Contents

Page

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RANGE SURVEYS--A FOUNDATION FOR RANGE MANAGEMENT

The basic management objective on range lands of western United States is to maintain a stable livestock industry by perpetuating and, in many instances, by increasing the productiveness of range lands. Experience has shown that hit-and-miss methods of range utilization often result in deterioration of the forage supply and productivity of the land. With the ever-increasing demand for range forage the necessity for planned use of the resource has been recognized and management plans are being developed whose aim is to provide for the most efficient livestock production consistent with other uses of the range and without injury to the better forage species, soil, or other renewable resources.

The stockman, in meeting this objective on his own lands, endeavors to control range use to a degree that will not jeopardize future returns from the land. He is confronted with the problems of fulfilling his seasonal needs for forage, obtaining proper distribution of livestock, and providing for the perpetuation of the most important forage plants. On public range

1/ The study reported herein was conducted cooperatively by the Forest Service and the Soil Conservation Service. The authors gratefully acknowledge their indebtedness to several members of these agencies who have been especially helpful in the preparation of this report; particularly to J. G. Osborne, who helped in the experimental design and the analysis of the results, to W. R. Chapline for his many helpful suggestions and critical review of the manuscript, and to Walt L. Dutton and F. G. Renner, whose interest was instrumental in initiating and in carrying through the project.

lands the administrator is called upon to provide a range-management program which harmonizes efficient harvest of the range forage with the social and economic welfare of the population dependent on the range resource for a livelihood. He correlates use of the range forage with watershed protection, game conservation, recreation, timber production, and other legitimate demands on the area. To do this requires careful study of the problems involved in the use of the range resource and the formulation and application of sound plans for its effective management.

Range surveys are the first step towards putting into effect a sound, practical plan for management of the range resource (1). They are the systematic inventory and analysis of all factors relating to the use of the range that precede the drafting of a plan to manage the forage resource effectively on administrative units such as a national forest, a grazing district, or a range in private ownership. Their primary purpose is to furnish the basis for determining how much and what kind of use may be made of the range forage crop annually in order to achieve the objectives of good range management. Surveys furnish an inventory of the amount of vegetation present on the range and its value to grazing animals. They also furnish the basis for determining how to obtain the best use of the forage. Definite information on important range problems brought to the owner's or the administrator's attention as the result of range survey data analysis stimulates and crystallizes planning improved practices that can be effected with a definite action program. Basic data obtained from range surveys assist in correlating use of the range forage with the management of other resources. On a

range unit grazed by a band of sheep or herd of cattle, range surveys serve as a basis for future constructive range management. The data shown in place on the maps are guides to the number of livestock that should be permitted to graze, to periods of time that should be spent in rotation units, to pounds of salt that should be distributed at specific locations, to needs for water development, and to many other management features. Problem areas such as lands seriously eroding, rodent concentrations, and poisonous plant infestations are properly emphasized. Range-management plans for each grazing allotment aid in correcting specific problems and in keeping account of the progress made in their solution.

The purpose of this publication is to outline the characteristics of a range survey method whose data are to serve as a basis for planning effective range management and to show from the results of a study the relative ability of methods now considered standard (4) to fulfill the requirements of a good range-survey method. It is believed that the contents of this publication will be of material aid to those who are dealing with range-management problems.

DEVELOPMENT OF RANGE SURVEYS

Soon after the administration of the national forests was undertaken by the Federal Government it was recognized that to get the best use of the range forage, both from the standpoint of conservation and protection of the forest resources and in fulfilling the needs of the stockmen using the range, required carefully planned management. At first plans for managing the range resource were developed from knowledge of the range conditions accumulated through range inspections. While it was found that

systems of managing the range could be developed over a period of years through periodic inspections of the range, it was often a slow process to accumulate sufficient information upon which to base a sound, practical plan for applying better methods of handling both the livestock and the range. Range surveys were developed as a means of quickly inventorying the range resource and of gathering other data needed for the preparation of range-management plans so that the necessary major administrative adjustments might be made speedily and yet be based on sound, detailed information on range conditions.

Range surveys or "grazing reconnaissance", as they were called at that time, were originated in 1907 by Dr. James T. Jardine, then an inspector of grazing in the U. S. Forest Service. He was instrumental in their development from 1907 to 1910 and the first range survey on a party basis was made under his supervision in 1911 (1, 6, 7) on the Coconino National Forest in northern Arizona. Although the present methods of securing and analyzing range-survey data have been somewhat altered from those originally employed, the character of range surveys and the use to which they are put have not changed. The objectives, the kinds of data obtained, and the kind of use made of the data from a completed range survey are much the same today as was the case in the procedure developed by Jardine. The method of determining the amount of forage on the early range surveys (8, 10) was much the same as described for the reconnaissance method in the Instructions for Range Surveys issued in 1937 (4).

A recent development in range-survey procedure has been the adoption of the square-foot-density method (9) for estimating the amount and composition of vegetation. The square-foot-density (point-observation-plot)

method was originated in 1932 by Dr. George Stewart and Selar S. Hutchings of the U. S. Forest Service. The method, developed during the period 1932 to 1936, was adopted as a standard range-survey procedure in 1937.

With the two methods of estimating vegetation on range surveys now in common use the term "range surveys" has been substituted for the original term "grazing reconnaissance." The term "reconnaissance method" is generally used to distinguish the method of estimating forage developed by Jardine from the square-foot-density method.

RANGE SURVEY METHODS

In order to provide information which will adequately fulfill the needs of practical plans for managing the forage resource, data collected by range surveys should include: (1) An accurate map showing the forage types and subtypes and the physical features of the area surveyed; (2) a reliable estimate of the amount, kind, and distribution of the forage on the range together with the proper forage requirement factor for converting these estimates to grazing capacity; and (3) a detailed description of the problems in range and livestock management on the area supplemented with proposed corrective measures. A complete inventory of all these data is needed in determining the best plan for managing the range. Weakness in any phase will materially lessen the usefulness of the survey as an aid in accomplishing the objective of range management.

MAPPING

To be of the greatest permanent value, the data collected on range surveys must be shown on maps so as to represent actual field conditions reduced to a scale which will enable the administrator to comprehend

the character of the resource on each area in relation to that of adjacent areas and to the resources of the whole administrative unit. These maps show in place: (1) The kind and amount of forage; (2) problem areas such as location and extent of accelerated erosion, poisonous plant infestations, rodent infestations, and areas of forage depletion; (3) topographic features which influence the management of livestock such as livestock barriers, drainage, and water supply; (4) cultural features including roads, trails, water developments, fences, corrals, and buildings; and (5) land ownership if it affects the management of the area.

Mapping the location, area, and composition of vegetation types is essential for planning and administering range lands because range conditions and most management problems are closely associated with kind of forage. Areas within which the vegetative cover is broadly similar are segregated into types. These types are further divided into subtypes on the basis of plant composition.

Vegetation types are determined by the general appearance of the vegetation. For example, untimbered upland range on which perennial grasses predominate is classified as grassland type. However, if similar range supports even a very sparse stand of trees, provided they are scattered evenly over the area so that an impression of a forested tract is gained, the type rightfully may be designated "conifer" or "broadleaf", depending on the dominant tree species. In other instances the tract may be a relatively level area on the flood plain of a stream or adjacent to a lake and may be vegetated primarily with a sward of grasses and sedges. This situation is rightfully classified as meadow type, either wet or dry, depending on the abundance of soil moisture. However, if the tract

supports tree growth as in the foregoing example, it should be designated as a conifer or a broadleaf tree type. The classification of range types on maps by their over-all appearance to the examiner rather than by their forage composition is done for a definite purpose, that of ready field identification when using the map in future range administration.

There are 18 standard types recognized for range lands of western United States. These are designated by number for ease in field representation as follows: (1) Grassland; (2) meadow; (3) perennial weeds; (4) sagebrush; (5) browse-shrub; (6) conifer; (7) waste; (8) barren; (9) pinion-juniper; (10) broadleaf trees; (11) creosote; (12) mesquite; (13) saltbush; (14) greasewood; (15) winterfat; (16) desert shrub; (17) half-shrub; and (18) annual vegetation (weeds or grasses). These types, all easily recognized as major changes in the range vegetation, are shown in standard colors on the final range-survey map (4). This makes it possible for a person acquainted with the color legend and the scheme of type classification to recognize the general kind of vegetation occurring on a range with a minimum of map study.

The classification of forage by types based upon the general appearance of the vegetation does not fulfill the needs of the range manager. For management purposes, he should be able to visualize from the map the main forage species and the approximate amount of forage. Range surveys, therefore, further classify each type into what is termed a subtype on the basis of the kind, amount, and condition of the vegetation. Since the standard is broad for type classification and range vegetation is heterogeneous, a single large type usually is subdivided into several areas, each representing a subtype distinct by virtue of change in kind, amount, or

condition of range forage that are deemed important to the management of the range. For example, a grassland type, one part of which is predominately bluebunch wheatgrass (_Agropyron spicatum_) and the other part Sandberg bluegrass (_Poa secunda_), is carefully surveyed by the field examiner and is divided on the map into two subtypes by a boundary clearly apparent on the ground. Each of the subtypes is identified on the completed range-survey map by the standard number and color of the type, and in addition by a standard symbol of the predominate forage species. For example, an area shown on the map with yellow coloration and with the symbol 1-Fid is identified as a grassland subtype that is vegetated predominately with Idaho fescue (_Festuca idahoensis_). A range manager reviewing the map may, therefore, ascertain at a glance the reason and the importance of the segregation. In a similar manner, important changes in density of the same vegetation association or in the condition of the vegetation on an area important enough to be considered in managing the range unit are shown on the map as subtypes.

The basis of subtyping usually is to show separately on the map any part of a type on which the kind or condition of the vegetation will affect the number of animals the range will support or which will affect the range or livestock management. Subtypes should represent conditions which can be readily recognized in the field. Subtypes smaller than 10 acres ordinarily are not shown unless they represent areas of unusually high grazing capacity or are prominent landmarks.

Surface acreage and estimated forage acreage for each subtype are also shown on the completed map. For example, the figure $\frac{240}{20}$ appearing

Should forage acres be explained here?

within a subtype on a map denotes an area of 240 acres for the subtype on which there are 20 forage acres of usable forage.

Mapping Methods

Five important variations of mapping vegetation have been used in range surveys. These are: (1) The "gridiron" (grid) method; (2) the type-sampling method using aerial photographs; (3) the traverse-sketching method; (4) the triangulation method; and (5) the topographic method.

The gridiron method is a systematic survey of the range by traversing the area on parallel lines spaced at specified intervals. These lines are usually spaced at ½-mile intervals on "intensive" surveys or where vision is poor because of timber and at 1-mile intervals on "extensive" surveys. The method requires General Land Office maps or systems of traverse lines to serve as a base and to furnish mapping control. Field examiners, working alone, traverse the area on the parallel strips using a surveying compass for directional control and determining distances by pacing. At every opportunity, direction and distances are checked with section corners or traverse ties. Ground features encountered on or near the traverse lines are located quite accurately but, since type and subtype boundaries and other management features must be sketched to a distance of one-fourth mile on each side of the line, the mapping accuracy diminishes as the distance from the survey line increases unless much effort is expended in offsetting from the main strip. By this as well as by the other methods, mapping is usually done on the scale of either 2 or 4 inches to the mile.

The type-sampling method using aerial photographs now is used quite extensively when aerial photography (vertical projections) precedes the

range survey. By this method the field examiner maps directly on the contact prints without reference to section or township corners. Although the horizontal scale of these prints is somewhat distorted because of the variations in ground elevation, type lines may be drawn on the photographs by reference to trees, roads, drainages, or other features that appear on the photographs. The location of all cultural and physical features is checked on the photographs by the field examiner. These, together with the lines demarking types and subtypes, then are transferred from the contact prints to scale on the base map planimetrically. The aerial photographs serve as a mapping control although the examiner is aided if a planimetric base map showing drainage and roads in accurate detail is also provided. It is often necessary to locate by compass and pacing important features that are not evident on the aerial photographs because of a dense timber canopy.

The <u>traverse-sketching method</u> is based upon traverse lines established along main streams, ridges, trails, and roads by compass and chain or by stadia in such a manner as to permit the field examiner to sketch the forage types and subtypes and locate management features on each side of the traverse line. The traverse-sketching method has been little used in recent years except in steep, rugged country unsurveyed by the General Land Office, or for which no accurate topographic maps or aerial photographs are available.

The <u>triangulation method</u> (plane-table method) is based upon triangulation networks throughout the area to be surveyed. A primary network of triangulation stations is established on the main peaks by means of a theodolite or transit. From this a secondary network is established by means of a plane table or telescopic alidade. A third set of points are located by means of a topographic abney and an open-sight alidade. Using

these points for control the examiner sketches in the topography and the forage type and subtype boundaries. A trip into each subtype is made to record data pertinent to its use. The triangulation method is best adapted to rough topography and was used on many of the early surveys. In recent years the method has been little used.

The topographic method is based upon a topographic map that shows contours at not greater than 100 feet vertical intervals. By this method the examiner works "with the country", keeping located by reference to outstanding topographic features recognizable on the map. All mapping is done directly on the topographic map. The topographic method is best adapted to rough country. The method is most often used in an area that is too rugged to map by the gridiron method and for which topographic maps are available. The accuracy of the range-survey map drawn with reference to topography depends to a large extent on the accuracy of the topographic base map used.

THE FORAGE ESTIMATE

While traversing through each subtype the examiner makes an estimate of its forage value. He determines the amount of vegetation (density) and the percentage of the whole vegetation which can be expected to be utilized under proper management (percent palatable). The product of these two quantities (forage factor) expresses the relative forage value of the average acre on the subtype which when multiplied by the acreage of the subtype gives the forage value of the subtype as a whole (forage acres).

Estimating Density

Density is defined as the percent of the ground area covered by vegetation within reach of livestock. Density is estimated either in square feet per sample plot (usually 100 square feet in size) or in the average percent of ground area that is covered. In either case it represents the vertical projection of the vegetation on the ground surface. The density of upright plants is the amount of ground surface that appears to be covered when the vegetation is viewed from directly above. For spreading weeds, browse, or open clumps of grass, the density estimate is made of the vegetation as it would appear if held together or raised at an angle so that all of the normal interstices between the leaves were completely filled, yet avoiding undue crowding. For browse species, current twig growth as well as leaves is considered in the density estimate. Two-story vegetation, such as grass growing beneath shrubs, is given a density value for each story if both are readily available to livestock.

Because of the large areas for which knowledge of the amount of forage is needed and because of the difficulty in actually measuring herbage production, it is necessary to rely on methods by which an estimate of the average density of vegetation on each subtype is obtained. Two methods of estimating average vegetation density are now considered standard by all public agencies engaged in making range surveys in western United States. These, previously referred to and both widely used, are the reconnaissance and square-foot-density methods.

Reconnaissance Method

The reconnaissance method is based upon the judgment and ability of the field examiner to visualize the average amount and composition of range forage on areas of considerable size. It usually is considered to be an over-all estimate method because a single write-up of the forage, based upon the field examiner's "size-up" of the vegetation, is made on type and subtype areas varying in size up to 640 acres or more. Actually, in field use, the reconnaissance method includes some aspects of a sampling method. In estimating average vegetation density and composition the field examiner usually proceeds into each subtype until he is satisfied that he is acquainted with the vegetation on it. He then selects a definitely bounded area that he considers to be essentially typical of the vegetation density and composition of the subtype. On this area he estimates the percent of ground covered by vegetation (density) and checks this by estimating the percent of ground not covered with vegetation. The two estimates should equal 100 percent. Having determined the density of all the vegetation he then obtains values for species by deciding what percent each makes up of the density. These species estimates, known as percent composition, should equal 100 percent when summed. The percent composition is obtained by first estimating the percent that each class of vegetation (weeds, grasses, and browse) is of the total vegetation. Percent composition values are then assigned to the species in each vegetation class in proportion to the examiner's opinion of their abundance. After completing the forage write-up of the sample area, the examiner continues his inspection of the subtype checking density and percent composition as he goes by recording at intervals the density of all the vegetation and the percent

composition of the main classes of vegetation. If important changes in density or composition occur, the examiner checks them against his specific write-up and revises it accordingly. If density and composition changes are major, he usually selects another "typical" area and makes a new estimate which he may substitute for the first or average with it. Seldom are more than two complete write-ups of typical areas made to obtain an average for the subtype with this method. More frequently the first is revised in light of vegetation changes noticed later in the subtype. The revision is based on average density and composition figures obtained from the periodic estimates made on the subtype subsequent to the initial write-up.

Square-Foot-Density Method

The square-foot-density method was originated in an attempt to overcome bias and personal error in estimating density and composition. It differs from the reconnaissance method in two respects. First, it is strictly a sampling method in which density estimates are limited to impersonally selected plots, and second, the density of each species on each plot is considered separately in obtaining average density for the subtype.

In estimating density on the sample plot by the square-foot-density method, the examiner counts the square feet of ground covered by each species within the plot, using a square frame of one-foot dimension as a guide to his estimate. A circular plot 100 square feet in area is used, which makes one square foot of ground covered by vegetation equivalent to a density of 1 percent. Estimates are made for each species that exhibits

a density of 0.5 square foot (0.5 percent) or more. The density of all vegetation on the plot is obtained by adding these figures. After the density of each species has been estimated for a plot it is a common practice to estimate density of all the vegetation on the plot to check the reliability of the sum of the species densities as well as to determine if any species is overlooked. Another useful check is to balance the sum of the density estimates against an estimate of the square feet of bare ground to be found on the plot. The sum of the two should be 100 square feet. This latter checking method is most useful on meadows where the vegetation is so densely interwoven that it is difficult to obtain dependable estimates of the individual species. The average density by species for each subtype is obtained by averaging density estimates taken on a number of sample plots.

The plots usually are distributed on the range by one of three standard procedures: (1) Spacing at equal intervals through each section along a grid of parallel traverse lines; (2) spacing at equal intervals along lines that bisect or otherwise sample each subtype separately; and (3) a combination of (1) and (2). When the grid procedure of mapping is used, plots are distributed along the route of travel at an intensity of 10 per mile. With the "intensive" procedure, two strips one-half mile apart are surveyed through each section and density is estimated on 20 plots spaced at 8-chain intervals (1 chain = 66 feet) on the survey lines and beginning at a distance of 4 chains from the section line. The "extensive" method, in which only one line is surveyed through each section, requires but 10 plots per square mile. Density estimates for plots that fall in the same subtype are summarized to obtain the average density for

each subtype. When the plots are spaced at predetermined intervals on transects that independently sample individual subtypes (type-sampling procedure), the number of plots needed for each transect is determined by the size of the subtype. The standard procedure (4) specifies that at least three plots be taken in a subtype of from 10 to 20 acres in area, 5 plots in subtypes of from 21 to 80 acres, and 10 plots in subtypes of 81 to 640 acres. If the subtype is larger than 640 acres, the number of plots is increased proportionally. On some surveys the number of plots is increased when sampling meadows and other high-grazing-capacity types. By the combination procedure, plots are taken at the same intensity and in the same manner as for the grid procedure, but in addition enough extra plots are put in the subtypes of high value to fulfill the requirements of type sampling. This combination is used primarily on ranges where small areas of high forage value are surrounded by large areas low in forage value. Under these conditions it is assumed that the gridiron plot network will obtain a satisfactory sample of the low-value types, while sampling of the smaller types which contain an important amount of the total forage needs to be supplemented by extra plots.

COMPUTING GRAZING CAPACITY

Forage Factor

Forage factor is an expression of the relative forage value of a subtype. It is a decimal fraction obtained by multiplying the average density of each species by its proper-use factor.

The proper-use factor (previously known as "palatability") of a species is the percentage of the entire volume of the current year's

growth of the species within reach of livestock that will be utilized under proper range practices. The factors for range forage species are determined by research in range utilization or from records of careful observations of forage use on ranges when they are approximately properly utilized. In instances where such data or records are lacking, it is necessary to rely on the judgment of qualified men in assigning proper-use factors. Factors which have to be considered when assigning a proper-use rating to a species are: (1) Class of livestock; (2) season during which the range will be grazed; (3) associated vegetation; (4) regional distribution of the species; (5) kind of management; (6) habits of the livestock; and (7) any regrowth of the plants.

To compute the forage factor from data obtained by the reconnaissance method, the percent composition of each species is multiplied by its proper-use factor expressed in percent (figure 1). The results are added to obtain the weighted proper-use factor (percent palatability) for the subtype. The weighted proper-use factor is multiplied by the density of vegetation to obtain the forage factor. The forage factor of a subtype is computed in the case of the square-foot-density method by multiplying the average densities of species by the proper-use factors and adding the resulting figures (figure 2).

Forage Acres

Forage acreage of a subtype is computed by multiplying forage factor with surface acreage. Forage acreage quantitatively measures relative forage value of the subtype. A forage acre, theoretically, is an acre of range completely covered with foliage that properly can be

Form 764a (Front)
(Rev. February 1940)

RANGE SURVEY WRITE-UP SHEET
RECONNAISSANCE METHOD

Project Starkey Range No. 14

Examiner J. Doe Date 7/16/40

Type 6-PP-Cru Location T4S., R34E. W.M (Twp. and range—aerial photo No.)

Total density ______ Timber PP (Composition) Cutover (Condition)

Forage density .35 % Pal. 33.2 PP (Reproduction) Scattered (Density) Sapling (Age)

F. A. Factor .116 For C+H (C&H or S&G) None (Injury) ______ (Cause)

Utilization cuts ______ Slope ______%. Timber ______%. Rocks ______%. Lack of water ______%. Erosion ______%. Unstable soils ______%. Total cut None

Net forage factor .116 C. and H. Net forage factor ______ S. and G.

PRINCIPAL FORAGE SPECIES

Weeds % 40	%	X P.U.*	Grasses % 55	%	X P.U.*	Shrubs % 5	%	X P.U.*
Hso	15	6.0	Cru	30	6.0	SYM	3	.3
Lsl	5	1.0	Cge	10	5.0	Ros	2	.4
Bsq	10	4.0	Fid	10	6.0	Spc	T	—
Ala	5	1.0	Din	1	.7			0.7
FRG	5	—	Pne	1	.7			
SED	T	—	Asp	3	2.1			
		12.0			20.5			

12.0	.332
20.5	x .35
0.7	1660
33.2	996
	.11620

D	W	G	S	
.35	45	55	0	
.30	50	40	10	
.40	25	70	5	
1.05	120	165	15	(Totals)
.35	40	55	5	(Averages)

*Proper use factor.

16—12890

Figure 1. Write-up of the vegetation on a subtype by the reconnaissance method.

FORM 764B
Revised March 1. 1939

RANGE SURVEY WRITE-UP SHEET
SQUARE FOOT DENSITY METHOD

Type No. 14
Transect No.

Project Starkey Range

Examiner John Doe

Date 7/16/40

Type 6-PP-Cru

Location T4S., R34E W M
S., T. & R. -- Aerial Photo No.

Surface Acres 100

Forage Acres 11.5

F. A. Requirement .25 For C+H (C&H or S&G)

Grazing Capacity — Months 46 For C+H (C&H or S&G)

Utilization Cuts:— Slope ___% Timber ___% Rocks ___% Lack of Water ___% Erosion ___%
Unstable Soils ___% Total Cut ___% Net Forage Factor ___ S&G

Net Forage Factor .115 C&H

SPECIES DENSITY BY PLOTS

SPECIES	PLOT NUMBER 1	2	3	4	5	6	7	8	9	10	TRANSECT DENSITY	AVERAGE DENSITY	P.U.†	F.F.
TOTAL	36.0	43.5	33.0	30.5	31.0						174.0	34.8		
Cru	17.5		9.5	15.5	10.0						52.5	10.5	20	.0210
Cge	5.0	1.0	7.5	2.0	2.0						17.5	3.5	50	.0175
Fid		14.5	3.0								17.5	3.5	60	.0210
Din					1.5						1.5	.3	70	.0021
Pne	0.5			0.5	0.5						1.5	.3	70	.0021
Asp		3.0	1.0		1.0						5.0	1.0	70	.0070
Hso	7.0	11.5	3.0	3.5	1.0						26.0	5.2	40	.0208
Lsl					9.0						9.0	1.8	20	.0036
Bsa		10.0	5.0		2.5						17.5	3.5	40	.0140
Ala	1.0	3.5	3.0		1.0						8.5	1.7	20	.0034
FRG	2.0			7.0							9.0	1.8	0	—
SYM	3.0				2.0						5.0	1.0	10	.0010
ROS			1.0	2.0	0.5						3.5	.7	20	.0014
														.1149

†Proper use factor

Figure 2. Write-up of the vegetation on a subtype by the square-foot-density method.

utilized by livestock. This situation does not exist in nature, for in the case of meadows which may have nearly a complete or 100 percent density, the plant cover can seldom be maintained successfully if the foliage is repeatedly used more than 80 percent. Forage acreage, therefore, is always less than surface acreage. The reduction from surface to forage acreage essentially is the elimination of all ground surface except that covered by foliage which properly can be grazed by livestock.

Forage-Acre Requirement

Forage-acre requirement is the factor used to convert forage acreage to an estimate of grazing capacity. True grazing capacity of a range area is the amount of grazing it can support over a long period of years under the proper range-management system without injury to the forage resource or other land values. The proper level at which to establish grazing capacity, therefore, is not higher than the level of forage production in the average climatic year. In regions where drought recurs, grazing capacity must be based upon forage production somewhat below the average as a precaution during dry periods against undue loss in condition of livestock and serious injury to the range resource.

Range surveys are made under many different weather conditions, and consequently measure plant densities that may be considerably above or below normal. This fluctuation in density value results in a determination of forage acreage higher or lower than average, depending on the climatic condition prevailing. In order that the calculation of current forage acreage on a range area be reduced to an estimate of its true grazing capacity it is essential that the forage-acre requirement

be developed for each range-survey project.

The general procedure in developing a forage-acre requirement is to select one or preferably more pastures or well controlled range units within the surveyed area on which the number of livestock grazed has been accurately recorded for several years and which exhibits vegetation and soil in good condition. The average number of livestock grazed and the average grazing period are determined and expressed in terms of sheep months, cow months, or animal units (one cow or its equivalent for one year). The forage acreage of the pasture or range unit as determined by the range survey is divided by this use figure to obtain the forage acreage required to support a sheep or a cow for one month or for an animal unit. This factor may then be used to convert forage acres on the remainder of the surveyed area to estimates of grazing capacity. Reduced to a formula, grazing capacity as estimated by range surveys is computed as follows:

$$\text{Grazing Capacity} = \frac{\text{Density x Proper-use factor x Surface acres}}{\text{Forage-acre requirement}}$$

CHARACTER OF RANGE SURVEYS

Range surveys furnish a basis from which to start a range-management program. They do not give the final solution to all the problems that arise in managing the resource. Management plans based upon range surveys need to be followed by an intensive, objective range inspection the year they are put into effect to decide whether the recommended action is sound and practical. Revisions of the management plans should be made as knowledge of the range is increased by subsequent inspections.

Range surveys are of the most value when followed by a prompt, effectual action program. If deleterious processes are allowed to continue

unduly after the inventory is made, the value of the inventory naturally diminishes. Vegetation changes may occur to the extent that the survey data cease to represent conditions on the range.

Most controversy over the results of range surveys centers on their estimates of grazing capacity, especially if these estimates happen to be substantially lower than the number of animals being grazed on the range in question. Admittedly, the survey method is subject to error in obtaining the estimated figure even though results of range surveys, properly made, have been good. However, if careful study indicates the grazing capacity to be lower or higher than that shown by the survey, the survey in no sense is invalidated, for the relative capacity values between different parts of the area still are usable and the entire capacity estimate may be raised or lowered as found to be necessary.

THE PRESENT STUDY[2]

The square-foot-density method or the reconnaissance method of estimating vegetation density is considered acceptable for use on range surveys (4). Both methods have been widely used by public agencies working on range problems. There has been much discussion of the merits of each, however, especially as to their relative accuracy, cost per acre

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2/ This study deals entirely with the adaptability of the reconnaissance and square-foot-density methods to administrative range surveys, one phase of which is the determination of relative forage values on different parts of the range. It was not designed to study the utility of the methods in range research where, for example, the measurement of treatment effects or trends requires that the dependability of vegetation inventories be expressed statistically. Therefore, the results presented in this report should not be interpreted to indicate the best method for obtaining vegetation inventories in range research. Such factors as desired statistical control or increased sampling accuracy conceivably could outweigh any advantages or disadvantages presented herein.

of field survey, and their effectiveness in gathering other data vital in the formulation of sound management plans for the area surveyed.

The two mapping procedures now most extensively used are (1) the grid or strip method and (2) mapping directly upon aerial photographs. The use of aerial photographs has recently been adopted as an improved method of mapping range forage. When aerial photographs are available for range areas, their use on range surveys involves the added cost of the contact prints and the cost of transferring type lines sketched on the prints in the field to proper scale on the planimetric base map. Whether improvement in the maps made from aerial photographs justifies the added cost has been questioned, because neither the weaknesses of mapping by the grid procedure nor the advantages of mapping on aerial photographs have been fully demonstrated.

A field test comparing the accuracy and costs of the two standard methods of estimating vegetation density and of the grid and aerial photograph mapping procedures was made in 1939 by the Pacific Northwest Forest and Range Experiment Station of the Forest Service in cooperation with the Soil Conservation Service. The study consisted of a comparison of separate range surveys of 27 sections made by five men using each of the four combinations of the methods of estimating vegetation and of mapping the forage. These combinations were: (1) The grid mapping procedure and reconnaissance method of sampling vegetation density (grid reconnaissance); (2) the grid mapping procedure and square-foot-density method of sampling vegetation density (grid square-foot-density); (3) the aerial photograph mapping procedure and the reconnaissance method of sampling vegetation

density (type-sampling reconnaissance); and (4) the aerial photograph mapping procedure and the square-foot-density method of sampling vegetation density (type-sampling square-foot-density). The purpose of the study was to determine which of these combinations most nearly fulfills the requirements of a good range-survey method as to accuracy of forage estimates, dependability of forage type maps, and cost. To make these comparisons the experiment was designed to: (1) Study the dependability of forage estimates obtained by the four survey methods; (2) determine variation of forage estimates with stage of plant development and degree of utilization; (3) determine if forage type maps made by the grid mapping procedure are as reliable as those made with aerial photographs; (4) determine the extent to which field examiners making the forage estimates will obtain supplemental data on range management; and (5) determine the relative costs of the four survey methods.

THE STUDY AREA

The area selected for study consisted of 27 sections of the Starkey Cattle Allotment on the Umatilla National Forest in the Blue Mountains of Oregon. Most of the area lay in the drainage of the Grande Ronde River, with a small portion on the ridge between the Grande Ronde and John Day Rivers. In general, the topography was gentle, there being approximately 1,500 feet difference in elevational range from the lowest to the highest parts. Two live streams and several intermittent streams cut through the area from west to east, breaking up the area somewhat, particularly in the northern part (figure 3).

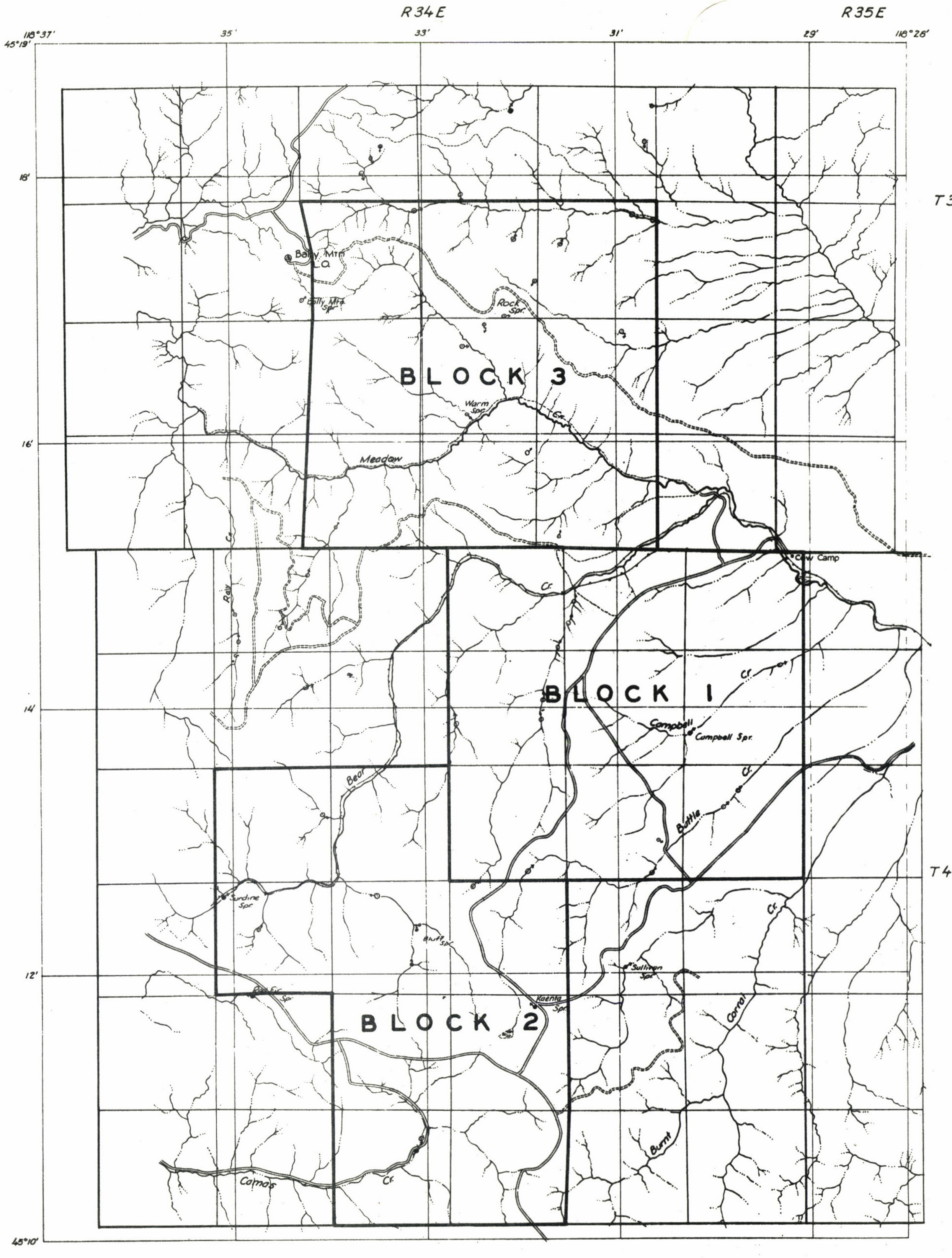


FIGURE 3.--DRAINAGE MAP OF THE EXPERIMENTAL AREA SHOWING THE ARRANGEMENT OF THE THREE 9-SECTION BLOCKS

The Starkey Cattle Range was selected as a suitable location for the study because it afforded a variety of conditions typical of those under which range surveys are made, both as to the kinds of forage and as to the management problems. It contained some types and subtypes with rather distinct boundaries and others where changes in composition were gradual or, at least, not pronounced. An opportunity to study the effect of these varied conditions on the resultant maps was thereby offered. The area selected contained range in good condition as well as some in poor condition; range consisting largely of bunchgrasses as well as of single-stalked grasses, weeds, and shrubs in mixture. Management problems were those of obtaining equitable distribution of cattle on relatively low-quality pinegrass range interspersed with grassland and meadow openings and of maintaining and improving the condition of grassland and meadow types.

The Vegetation

The vegetation on the Starkey Cattle Allotment consisted of grassland and dry meadow types on south slopes, ridges and benches, stringer meadows along the streams, and a mixture of timber types some of which contained bunchgrasses and others a pinegrass-weed-browse mixture as the understory vegetation. Numerous timber thickets which are considered waste range on cattle allotments occurred.

The grassland types that usually occurred on south slopes, ridges, and benches, were vegetated principally by perennial grasses with some weeds in mixture. The main grass species were Sandberg bluegrass (*Poa secunda*), bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), onespike oatgrass (*Danthonia unispicata*), and

and junegrass (Koeleria cristata). Weed vegetation included western yarrow (Achillea lanulosa), pussytoes (Antennaria spp.), Wyeth eriogonum (Eriogonum heracleoides), mules-ears (Wyethia amplexicaulis), and arnica (Arnica fulgens).

The dry meadow types contained many of the species found on the grassland types, but deep soil, gentle topography, and natural irrigation from seasonal springs and seeps gave a more vigorous growth and produced considerably more forage.

Stringer meadows occurring along the stream courses contained a variety of grasses and weeds, and some shrubs. Kentucky bluegrass (Poa pratensis), sedges (Carex spp.), timothy (Phleum pratense), and redtop (Agrostis alba), were the most common grasses and grasslike plants, while glandular cinquefoil (Drymocallis glandulosa), cinquefoil (Potentilla spp.), western yarrow, bluebells (Mertensia spp.), and Alaskan burnet (Sanguisorba sitchensis) were some of the many weed species occurring. Browse species were mainly willows (Salix spp.) and alder (Alnus spp.).

Timber ranges were largely of two kinds, those with a bunchgrass understory and those containing a pinegrass (Calamagrostis rubescens)-weed or a pinegrass-shrub mixture. Timber range containing bunchgrasses usually were under open stands of ponderosa pine (Pinus ponderosa). The herbaceous vegetation consisted largely of Sandberg bluegrass, Idaho fescue, bluebunch wheatgrass, junegrass, western yarrow, pussytoes, lupines (Lupinus spp.), and elk sedge (Carex geyeri). This condition was quite typical of benches, ridges, and south slopes. The more dense timber stands consisted of ponderosa pine, Douglas fir (Pseudotsuga taxifolia), and lodgepole pine (Pinus contorta), with some larch (Larix occidentalis). The understory

vegetation included many grasses, weeds, and browse species. The main grasses were pinegrass, elk sedge, Wheeler bluegrass (_Poa nervosa_), timber oatgrass (_Danthonia intermedia_), and needlegrasses (_Stipa_ spp.). Some of the weeds were heartleaf arnica (_Arnica cordifolia_), lupine, western yarrow, old man's whiskers (_Sieversia ciliata_), cinquefoil, woollyweed (_Hieracium scouleri_), glandular cinquefoil, strawberry (_Fragaria_ spp.), pentstemon (_Pentstemon_ spp.), and pussytoes. Browse species included snowberry (_Symphoricarpos_ spp.), wax currant (_Ribes cereum_), wild rose (_Rosa gymnocarpa_), bitterbrush (_Purshia tridentata_), common serviceberry (_Amelianchier alnifolia_), and little grouse whortleberry (_Vaccinium scoparium_).

The forage composition varied considerably within the type, from nearly pure stands of pinegrass in some places to a predominance of browse and weed vegetation.

Waste range was limited to areas in which timber stands were too dense for reasonable access to livestock. The typical conditions that constituted waste range areas were thickets of lodgepole pine reproduction or dense, mixed stands of lodgepole pine, Douglas fir, grand fir (_Abies grandis_), larch, and Engelmann spruce (_Picea engelmanni_). These usually occurred on north slopes, stream bottoms, or eastern aspects at higher elevations.

THE METHODS STUDIED

Mapping by Grid Procedure

The "intensive" method, requiring that field examiners go twice through each section, was used when employing the grid mapping procedure. Section corners and quarter corners established by the General Land Office were used for control. The forage types were sketched by the field

examiners on base maps drawn from General Land Office surveys. Boundaries between types and subtypes were drawn by referring to features already on the map and by use of control carried forward by compass and pacing. The examiners drew boundaries between types and subtypes, made forage write-ups, and located springs, fences, salt grounds, and other management features for a distance of one-fourth mile on either side of the traverse line. Strips were run parallel to and one-fourth mile from the section lines.

Use of Aerial Photographs

When using the type-sampling procedure all mapping was done directly on aerial photographs, these data later being transferred to scale from the photographs to the planimetric base map. Boundaries between types were drawn on the photographs by the chief of party to insure that the same forage would be sampled by all examiners. This special procedure was deemed necessary in order to permit direct comparisons by types between forage estimates made by the square-foot-density and reconnaissance methods. This procedure is sometimes followed on range surveys, but the most common practice is to permit field examiners complete freedom in drawing type boundaries on aerial photographs. It was felt, however, that predetermination of type boundaries as used in the study would not give material advantage to the survey methods that employ aerial photographs for type mapping. By use of aerial photographs, the examiner can determine his location with reference to the forage to be sampled quite accurately regardless of whether he draws the type boundaries himself or whether they have been predetermined. Moreover, major changes in

vegetation usually are sufficiently apparent on the photographs to permit easy and dependable location of type boundaries. Wide latitude for personal judgment in depicting type boundaries on aerial photographs occurs only in instances of obscure or gradual vegetation changes. All springs, salt grounds, fences, or other range improvements and the streams encountered by the examiner were drawn directly on the photographs in the field.

Reconnaissance Method

When employing the grid mapping procedure and the reconnaissance method of estimating forage, write-ups were made by the field examiner as he proceeded along each strip, a separate write-up being made in each half section[3/] for each subtype which exceeded 20 acres in area. Examiners took enough offsets from the line of travel to see a representative sample of the forage on each subtype and to locate boundaries between subtypes. Vegetation write-ups were made for each subtype that the examiner felt was important in obtaining a good forage estimate of the area and which would be useful in guiding future range management. These included areas outstandingly different in range condition or in kind of vegetation. In surveying types whose boundaries were predetermined on aerial photographs, cardinal directions were not strictly followed, but the vegetation write-ups were made by half sections in the same manner as for the grid procedure. When making forage estimates of subtypes, the procedure as previously described for the reconnaissance method, which includes techniques that are considered essential to good results, was strictly followed.

3/ For all methods forage estimates were made on each half section to provide two independent estimates within each section. In the analysis these estimates were found unnecessary, and forage estimates were analyzed by sections.

Square-Foot-Density Method

When employing the square-foot-density method of estimating forage and the grid procedure of mapping vegetation and of distributing sample plots, twenty 100-square-foot circular plots were used per section, spaced at 8-chain intervals on two parallel lines one-half mile apart. The plots that occurred in each subtype were summarized separately to obtain the average estimate of forage on the subtype. Density of each species containing more than one-fourth square foot density was determined on each plot in the manner described by Stewart and Hutchings (9).

In the type-sampling procedure, the forage estimate of each subtype was obtained from a series of 100-square-foot plots spaced at equal distances along a line that followed the longitudinal axis of the subtype. The number of plots in each series varied with the size of the subtype and whether or not it was wholly within a single half section. Subtypes occurring wholly within a single half section were sampled by:

3 plots for areas of 10 to 20 acres.
6 plots for areas of 21 to 80 acres.
10 plots for areas of 81 to 320 acres.

Subtypes that extended into more than one half section were sampled with one-half the above number of plots within each half section. Thus a subtype of 300 acres occurring wholly within one half section was sampled with 10 plots. Should it occur in two half sections it was sampled with 5 plots placed in each half section. If it extended into three half sections 15 plots were used, 5 in each half section. Subtypes of less than 20 acres were sampled as a unit even if they occurred in two or more half sections. For subtypes of high grazing capacity, such as densely vegetated meadows, the number of plots was doubled.

FIELD EXAMINERS AND TRAINING

All field examiners who participated in the study had previous experience in estimating vegetation density and composition. One examiner previously had spent a season on a range survey that employed the reconnaissance method. He had also spent one month sampling vegetation by the square-foot-density method on a range-research project. A second examiner had one season's experience making range surveys using the square-foot-density method and also had one season's experience using the square-foot-density method on range-research projects. Two men had no previous experience on range surveys. Of these, one had two years' experience and the other one year's experience estimating density by the square-foot-density method on range-research projects. The fifth man had received several years' experience estimating vegetation density by the square-foot-density method on range-research projects and had experience both as field examiner and as chief of party on range surveys. All of his experience, however, had been with the square-foot-density method. Only one man, examiner 5, had previous experience in the use of aerial photographs.

Prior to beginning the field surveys for the study all field examiners were given 12 days of intensive training. This included instruction and training in the four survey methods to insure that the men could use all the methods in a manner comparable to a typical range-survey crew, and in addition a "conditioning" period during which surveys were made outside the experimental area to insure that field examiners were proficient in the use of the methods. In order to maintain uniform density and composition estimates throughout the survey the crew practiced estimates together

twice each week throughout the field season. Each Saturday all men practiced making forage estimates by both the reconnaissance and square-foot-density methods. Each Wednesday morning the men currently using the square-foot-density method practiced together in making forage estimates, as did the men currently surveying by the reconnaissance method.

EXPERIMENTAL DESIGN

The study was designed in such a manner as impartially to demonstrate the advantages and disadvantages of all four methods. The effects of personal bias and of increase in experience in estimating density, in maturity of the vegetation, and in degree of forage utilization as the season progressed were equally distributed among the methods by dividing the study area into three parts, each of 9 sections, and by the arrangement of the methods and field examiners on each part (table 1). Thus all four surveys were completed on one 9-section block by all five men before starting on the second. Likewise, all surveys were completed on the second block before starting the third. By this procedure, surveys were made by all methods on a single block at a time when the vegetation was at approximately the same condition (i.e., full bloom, drying, dry), when the vegetation had received approximately the same degree of utilization, and when all field examiners had acquired the same amount of experience from the study. The order of using the survey methods and the direction of travel followed by the field examiners were arranged in such a manner as to reduce to a minimum the effect of personal bias, increased familiarity with the country on the part of field men on their second, third, and fourth surveys of the block, and the effect of the topography (table 1). The order of

Table 1.--Arrangement of field work by 9-section blocks

Trip number	Mapping procedure	Man 1			Men 2 and 5			Man 3			Man 4		
		Range survey method	Direction of travel	Starting point	Range survey method	Direction of travel	Starting point	Range survey method	Direction of travel	Starting point	Range survey method	Direction of travel	Starting point
Block 1													
1	Grid	Sq. ft.	E-W	S	Sq. ft.	N-S	W	Recon.	E-W	N	Recon.	N-S	E
2	Grid	Recon.	N-S	W	Recon.	E-W	S	Sq. ft.	N-S	E	Sq. ft.	E-W	N
3	Type-sampling	Sq. ft.	E-W	N	Recon.	N-S	E	Recon.	E-W	S	Sq. ft.	N-S	W
4	Type-sampling	Recon.	N-S	W	Sq. ft.	E-W	S	Sq. ft.	N-S	W	Recon.	E-W	N
Block 2													
1	Grid	Sq. ft.	E-W	S	Sq. ft.	N-S	E	Recon.	E-W	N	Recon.	N-S	W
2	Grid	Recon.	N-S	W	Recon.	E-W	S	Sq. ft.	N-S	E	Sq. ft.	E-W	N
3	Type-sampling	Sq. ft.	N-S	E	Recon.	E-W	N	Recon.	N-S	W	Sq. ft.	E-W	S
4	Type-sampling	Recon.	E-W	N	Sq. ft.	N-S	W	Sq. ft.	E-W	S	Recon.	N-S	E
Block 3													
1	Grid	Sq. ft.	N-S	E	Recon.	E-W	N	Sq. ft.	E-W	S	Recon.	N-S	W
2	Grid	Recon.	E-W	N	Sq. ft.	N-S	E	Recon.	N-S	W	Sq. ft.	E-W	S
3	Type-sampling	Recon.	E-W	S	Recon.	N-S	W	Sq. ft.	E-W	N	Sq. ft.	N-S	E
4	Type-sampling	Sq. ft.	N-S	W	Sq. ft.	E-W	S	Recon.	N-S	E	Recon.	E-W	N

methods and directions of travel used by each field examiner was selected as follows:

(1) Surveys by the grid procedure preceded those using aerial photographs.

(2) For the grid procedure and the type-sampling procedure two men used the reconnaissance method on their first survey over the block and two men used the square-foot-density method. One man surveying by each method went in a north-and-south direction through the section, whereas the other went east and west (table 1). On the second trip over the same area the field examiners went at right angles to the direction followed on their first trip.

(3) Men using different methods but traversing in the same cardinal direction were assigned different starting points on the block.

(4) The assignments of the men to methods, direction, and starting points were made at random for each block.

The only exception to the above arrangement was that men 2 and 5 were always given the same assignments, they being paired throughout the study. At no time was reference made to work previously completed and field examiners did not discuss range and forage conditions or management problems on the study area.

MEASUREMENT OF THE RANGE FORAGE

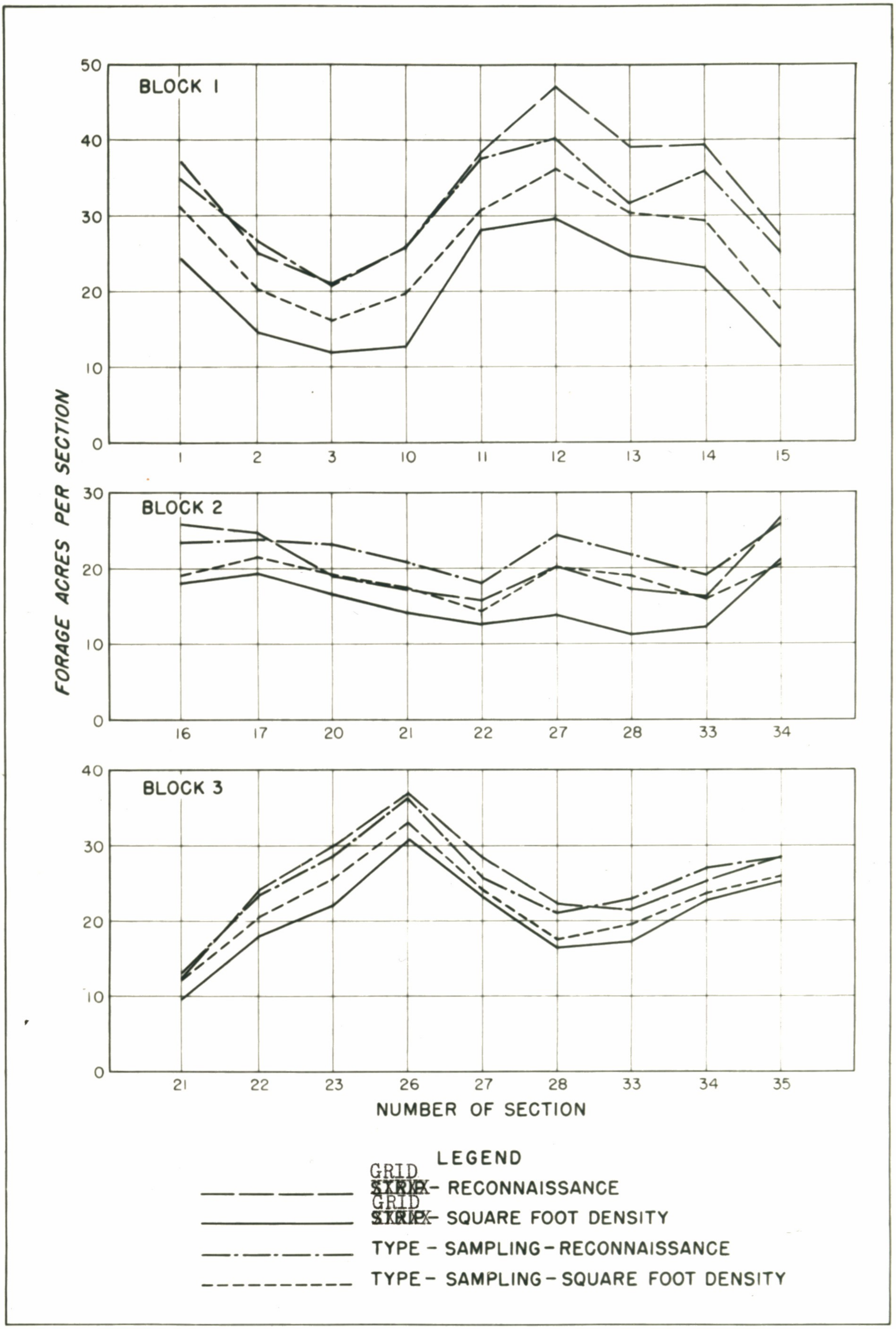
To be used effectively in planning for sound resource management, a range survey should furnish a reliable index to the forage. This is because the kind, amount, and distribution of the vegetation on a range forms the basis for determining the number of grazing animals that

properly can be grazed and the distribution of the livestock that should be obtained to make the most efficient use of the forage.

RECOGNITION OF RELATIVE FORAGE VALUES

Results from the study demonstrate that the standard range-survey methods give a good measure of the relative amount of forage on the different parts of the range. Although no absolute measure of the total amount of forage was available on the 27 sections studied with which to compare estimates made with the range-survey methods, the data indicate that both the reconnaissance and the square-foot-density methods using either mapping procedure effectively show relative forage values (figure 4). In comparing the average of the forage estimates by the five men, sections which were found to have an abundance of forage by one method usually were shown to have an abundance of forage by the other methods. Approximately the same average differences were recognized by all methods between sections with an abundance of forage and those with lesser amounts. For instance, on block 3 the amount of forage on section 21 was estimated as 12.4 forage acres by the grid reconnaissance method, 13.0 forage acres by the type-sampling reconnaissance method, 9.7 forage acres by the grid square-foot-density method, and 12.0 forage acres by the type-sampling square-foot-density method, as compared with 36.9, 36.2, 30.9, 33.2 forage acres by the methods respectively on section 26. Thus all methods gave approximately the same differences in forage value between the two sections; the grid reconnaissance method indicating that section 26 contained 3.0 times, the type-sampling reconnaissance method 2.8 times, the grid square-foot-density method 3.2 times, and the type-sampling square-

FIGURE 4



AVERAGE NUMBER OF FORAGE ACRES BY SECTIONS AS DETERMINED BY ESTIMATES OF 5 MEN FOR THE FOUR SURVEY ~~PROCEDURES~~ METHODS

foot-density 2.8 times as much forage as section 21. Similarly, all four methods showed section 26 (block 3) to contain between 1.7 and 1.9 times as much forage as section 28; section 20 (block 2) to contain 1.1 times as much forage as section 21; and section 21 to contain between 1.1 and 1.2 times as much forage as section 22. The fact that estimates by all methods yielded relatively similar forage values for the sections strongly indicates that any of the four standard methods can be used to measure differences in forage.

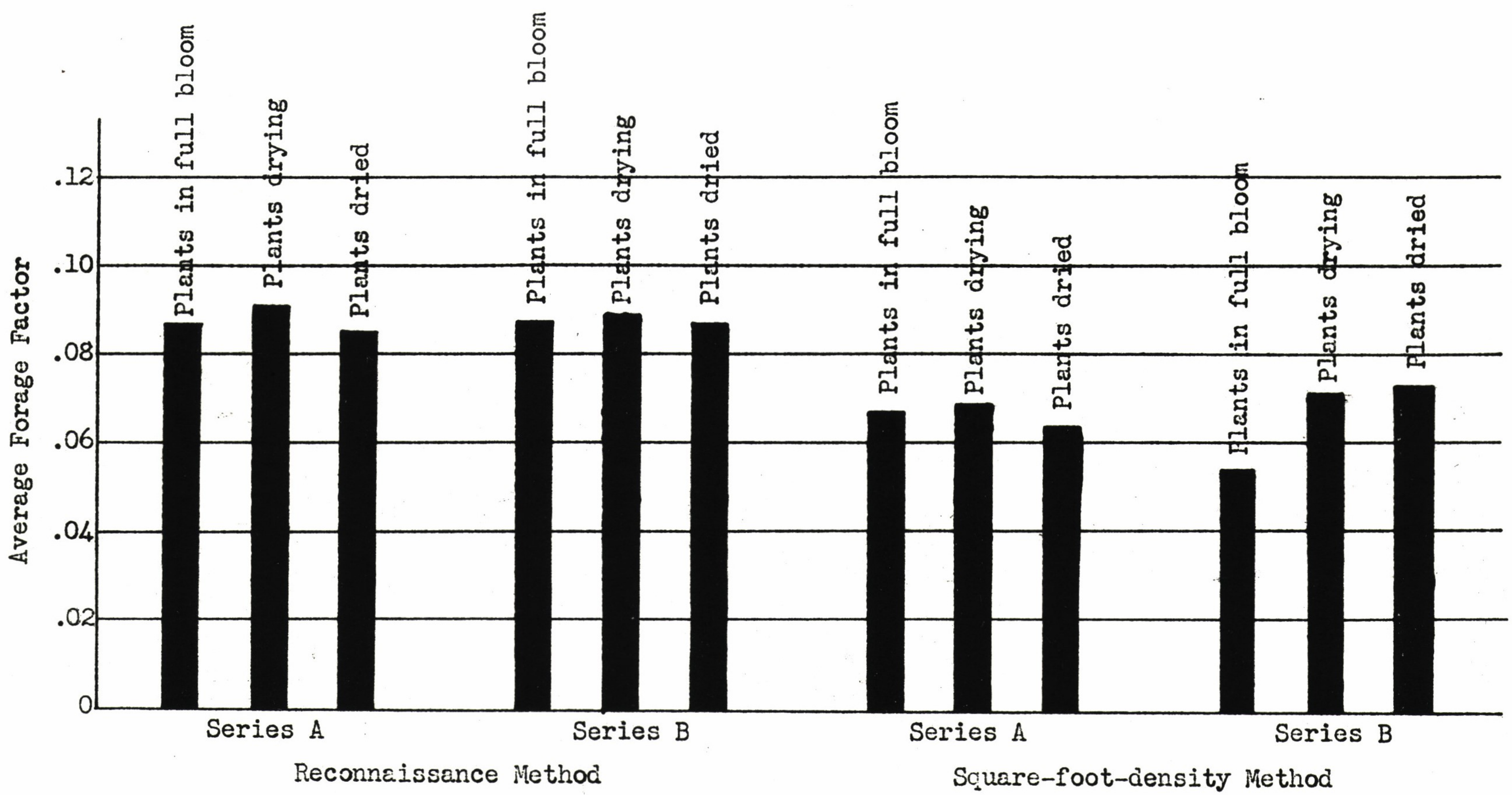
Both the reconnaissance and square-foot-density methods not only give good estimates of the relative forage values; but forage estimates made by these methods at different times during the field season are also comparable. This conclusion is based upon forage estimates made on the same plots at weekly intervals throughout the summer.

The variation in forage estimates as the season progressed was studied on two series (series A and B) of permanent plots, each consisting of three .15-acre contiguous plots and nine 100-square-foot plots. The 100-square-foot plots were spaced at 33-foot intervals, three within each .15-acre plot. Estimates of the density and composition of vegetation were made each week on each series of three .15-acre plots by the reconnaissance method and on each series of nine 100-square-foot plots by the square-foot-density method. The assignment of series of plots and methods of estimating vegetation among the field examiners was rotated in such a manner that no one man estimated the vegetation on the same plots by the same method in two successive weeks. During the forepart of the study the method used on the main survey during the current week determined the method assigned to each man when estimating forage on

the permanent plots. For example, the two men making range surveys using the square-foot-density method each estimated density on one of the series of nine 100-square-foot plots and the men surveying by the reconnaissance method each made estimates on one of the series of three .15-acre plots. This procedure was revised early in the study to one where each man followed a definite rotation, the men being assigned in the following sequence: Series A-reconnaissance, series A-square-foot-density, series B-square-foot-density, series B-reconnaissance. Throughout the study an effort was made to eliminate as much as possible any effect of previous estimates on the plots.

All forage-factor estimates made on these permanent plots by the reconnaissance method between June 17 and July 8, at the time when most of the vegetation was in full bloom and was lightly grazed, averaged .0866 for series A and .0876 for series B. Estimates made between July 8 and August 5, when the vegetation was drying and moderately grazed, averaged .0912 for series A and .0888 for series B. Between August 5 and September 2, when the forage was all dry and heavily grazed, the average forage factor on series A was .0856 and for series B was .0867 (figure 5). Similar comparisons between average estimates of forage factors on series A by the square-foot-density method were .0658 during the period of full bloom and light grazing, .0682 during the period when the vegetation was drying and was moderately grazed, and .0636 during the period when the vegetation was dry and had been heavily grazed. The average forage factors estimated by the square-foot-density method on series B for the same periods were .0538, .0704, and .0726, respectively. None of these forage estimates varied more during any one period from those made during

FIGURE 5.--AVERAGE OF WEEKLY FORAGE FACTOR ESTIMATES MADE ON THE SAME SERIES OF PLOTS DURING THREE 4-WEEK PERIODS WHEN THE VEGETATION WAS IN THE FOLLOWING CONDITIONS, RESPECTIVELY: (1) FULL BLOOM AND LIGHTLY GRAZED; (2) DRYING AND MODERATELY GRAZED; (3) DRIED AND HEAVILY GRAZED



the other periods than would have been expected had the men repeated their estimates during a single period (table 2).

FORAGE ACRES AN "INDEX" TO FORAGE

Forage acres obtained by range surveys should be considered only as an index to the relative amount of forage on the range. They do not always represent the same amount of forage, but vary somewhat for different surveys. Theoretically, a forage acre should represent a definite amount of forage, and it is often thought of as being equivalent to an acre of ground totally covered with vegetation which can be fully utilized under proper management of the range, a condition that does not exist in nature under the arid and semiarid conditions of the West. In actual practice, however, differences in density estimates, proper-use factors, amount of forage per unit of density of different plants, degree of slope, and other factors affect the value of a forage acre. For example, density estimates may vary between methods of estimating vegetation density and with any difference in density concepts that may occur between separate crews. Likewise the value of a forage acre varies for different kinds of livestock because of differences in their forage requirement. That the two methods of estimating range forage and the two mapping procedures may yield somewhat different numbers of forage acres was demonstrated by this study.

Effort was made throughout the study to maintain the same concept of density for both the reconnaissance and the square-foot-density methods of estimating vegetation. For both, all field examiners considered density to be the amount of ground which appeared to be covered when the

Table 2.--Variance analysis of forage-factor estimates[1] made on the same plots during three 4-week periods when the vegetation was in the following conditions, respectively: (1) Full bloom and lightly grazed; (2) drying and moderately grazed; (3) dried and heavily grazed

Source of variation	Degrees of freedom	All vegetation: Mean square	All vegetation: F[2]	Weeds: Mean square	Weeds: F	Grasses: Mean square	Grasses: F
Reconnaissance method							
Total	23						
Between men	3	.00060254	7.952**	.00000777	1.293	.00055068	9.673**
Between periods	2	.00003245	2.335	.00000699	1.163	.00000842	6.761
Between series	1	.00000004		.00017227		.00030317	
Interaction							
Man x period	6	.00003583	2.115	.00000365	1.647	.00003627	1.570
Error	11	.00007577		.00000601		.00005693	
Square-foot-density method							
Total	23						
Between men	3	.00021647	1.373	.00000165	2.297	.00042607	3.625*
Between periods	2	.00021245	1.348	.00001143	3.016	.00024294	2.067
Between series	1	.00000051		.00001768		.00000451	
Interaction							
Man x period	6	.00007472	2.110	.00000574	1.515	.00004288	2.741
Error	11	.00015766		.00000379		.00011755	

1/ For square-foot-density method average of forage-factor estimates on nine 100-square-foot plots. For reconnaissance method average of forage-factor estimates on 3 plots 1-1/2 square chains in area.

2/ F with no asterisk indicates differences shown are not significant.
* Differences shown significant at low level (1 in 20).
** Differences shown significant at high level (1 in 100).

vegetation was viewed from directly above. For spreading weeds and open clumps of grasses the foliage density was considered as 10/10 when pressed together or raised at an angle so that all the normal interstices or openings between the leaves were completely filled without unduly crowding the vegetation. For shrubs only the vertical projection of the current twig and foliage growth within reach of livestock was considered in the density estimate.

Despite the effort to maintain the same density concept, some differences resulted. Surveys of the 27 sections made by the reconnaissance method gave more forage acres than did the survey of the same area by the square-foot-density method (figure 4). The average number of forage acres per section determined by the reconnaissance method was 26.71 forage acres for the grid procedure and 26.13 forage acres for the type-sampling procedure as compared with an average of 18.76 forage acres per section for the grid procedure and 22.27 forage acres per section for the type-sampling procedure using the square-foot-density method. The number of forage acres obtained by the reconaissance methods was higher for all blocks than by the square-foot-density methods, except for block 2 where the ratio of the average difference between the number of forage acres by the grid reconnaissance and the type-sampling square-foot-density methods to its standard error was not sufficient to consider the differences shown to be conclusive (table 3).

Approximately the same relative differences were noted between forage estimates made by the methods on the two series of permanent plots previously mentioned. On these plots the average of all estimates made by the reconnaissance method during the 12 weeks from June 17 to

Table 3.--Average differences between forage estimates made by the four survey methods

Methods compared[1]	Average difference (forage acres per section)		
	Block 1	Block 2	Block 3
I - II	13.13**[2] ± [3].976	4.84** ± .606	4.84** ± .610
I - III	2.34 ± 1.033	-2.00 ± .872	.36 ± .467
I - IV	7.55** ± .798	1.77 ± .994	2.98** ± .493
II - III	-10.80** ± .674	-6.84** ± .748	-4.48** ± .434
II - IV	-5.59** ± .469	-3.07 ± 1.536	-1.86** ± .333
III - IV	5.21** ± .689**	3.77** ± .319	2.62** ± .271

1/ I - Grid reconnaissance.
II - Grid square-foot-density.
III - Type-sampling reconnaissance.
IV - Type-sampling square-foot-density.

2/ No asterisk indicates no significance shown.
* Differences shown are significant at low level (1 in 20).
** Differences shown are significant at high level (1 in 100).

3/ Average difference with standard deviation.

September 8 gave a forage factor of .0878 ± .0018.[4] The average forage factor estimated during the 12-week period on the same vegetation by the square-foot-density method was .0657 ± .0026, which was 74.8 percent of the forage factor estimated by the reconnaissance method. This difference is approximately the same as existed between the forage acres estimated on the 27 sections by the two methods, these comparisons being 70.2 percent and 85.2 percent for the grid and type-sampling procedures respectively.

Differences between forage estimates by the square-foot-density and reconnaissance methods similar to those shown have been noted by men familiar with both methods and a number of causes have been suggested. Some of these are: (1) In using the square-foot-density method where the estimate is made by square-foot units on a circular plot 11.3 feet in diameter, the examiner can stand at the plot center or walk around its perimeter, viewing all the vegetation from directly above, and therefore can base his density estimate strictly upon the vertical projection of plant foliage, whereas by the reconnaissance method, where the plants are more often viewed from a distance, there is a tendency to estimate the oblique projection, which would give a somewhat greater density; (2) by the square-foot-density method the vegetation is compressed mentally in an attempt to compensate for the interstices between the leaves, while with the reconnaissance method where less attention is given to individual plants, these openings may be overlooked; (3) dried vegetation of the previous year's growth, mixed with the green vegetation,

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4/ Unless otherwise specified, the number preceded by ± signifies the standard error of the mean.

may be included in a single over-all reconnaissance estimate but would be eliminated in the square-foot-density method because of the more thorough examination given each plant on the 100-square-foot plots; and (4) species totaling less than one-fourth foot density on each 100-square-foot plot are not included in the square-foot-density estimates but are included in the reconnaissance estimate of density though not in the composition breakdown. Which, if any, of these factors is the major cause of the differences between the methods was beyond the realm of this study.

By the square-foot-density method, the grid procedure gave approximately 16 percent smaller forage estimates than did the type-sampling procedure, whereas with the reconnaissance method there was no material difference in estimates of the number of forage acres obtained by the two procedures. This difference in forage estimates between the two mapping procedures by the square-foot-density method is due partially to the greater acreage of waste or nonusable range shown to be present when mapping by the grid procedure, and partially to the method of distributing the plots on the subtypes. The range classified as waste by the grid procedure (average of 5 men for 27 sections) was 19.7 ± 4.90 acres per section more than by the type-sampling procedure. This would account for less than one-fifth of the differences shown between the methods. A greater cause for difference arises from the methods of distributing the plots in using the two sampling procedures. The average of all forage estimates for openings (including grassland and meadows) gave a forage factor of .0404 ± .00144 when made by the grid procedure, compared to a forage factor of

.0518 ± .00111 estimated by the type-sampling procedure. In a like manner, estimates in coniferous timber range gave an average forage-acre factor of .0331 ± .00020 by the grid procedure compared to .0375 ± .00013 by the type-sampling procedure. It is reasonable to assume that the method of distributing the plots did not affect the men in their density estimates on the plots and that these differences occurred, therefore, from bias in distributing the plots on each type when using the type-sampling procedure.

THE NECESSITY FOR UNIFORMITY OF FORAGE ESTIMATES

The most important requirement of range surveys, so far as estimating grazing capacity is concerned, is that all forage estimates on a single survey be uniform. The fact that a forage acre may not be an equal value for surveys made by different crews, by different methods, or during different years does not destroy its usefulness in range surveying, provided uniformity of estimates is maintained throughout each survey during a single year. This uniformity throughout each survey is essential in order to furnish a reliable inventory of the distribution of the forage which can be used (1) as a dependable base for determining a forage-acre requirement for the area surveyed, (2) as a basis for determining grazing capacity, and (3) in the formation of a plan for livestock distribution on the area.

Uniform forage estimates are prerequisite to determining a dependable forage-acre requirement. Several range units whose forage, topography, and other features typify the range areas to which the requirement factor will be applied, whose management most nearly approaches satisfactory standards, and for which dependable records of animal months' use

for a period of years are available, are necessary to establish sound requirement factors. If, as usually is the case, both cattle and sheep graze on the surveyed range, separate forage-acre requirements need to be developed for each class of livestock. If, in addition, the range is segregated by topographic or climatic zones into spring-fall and summer or other combinations of seasonal range classes and particularly if livestock management differs by seasons, it is urgent to secure separate factors for seasonal ranges. For example, if fall range is grazed by dry ewes whereas adjacent summer range is used by ewes and their lambs, the same forage-acre requirement will not properly apply to both range classes. On the range units used for developing forage-acre requirements all of these varying elements must be weighed in arriving at a valid forage acreage necessary to support a grazing animal satisfactorily for a given period and to provide for sustained forage production. The sole constant in the formula is the amount of vegetation on the sample range unit. It is evident, therefore, if uniform forage estimates are not maintained within and between range units used in developing forage-acre requirements, that the results are undependable.

The forage-acre requirement properly developed on range units on which the grazing capacity is known or safely can be approximated is used to estimate grazing capacity on other areas covered by the survey for which the knowledge of grazing capacity is questionable or is wholly unknown. The range-survey method of computing grazing capacity for these areas consists of determining the forage acreage from estimates of the vegetation and dividing this amount by the forage-acre requirement. To insure the most dependable grazing-capacity estimates

area by area, forage estimates must be uniform between surveyed areas and also between areas from which the forage-acre requirement was developed and those for which grazing-capacity estimates are needed. In this connection it is important that forage-acre requirements be developed for each range survey, since plant density which is the basis of forage estimates fluctuates with annual precipitation, thereby affecting the value of a forage acre as it applies to grazing capacity.

Uniform estimates of forage are essential to the use of range-survey data as a basis on which to make plans for proper management. Range surveys should show the relative amount of forage on whole grazing allotments or ranches to serve as a basis for determining the grazing capacity of the allotment or ranch and also on smaller subdivisions of each allotment or ranch to furnish a basis for distributing the livestock. It is not sufficient to know how many cattle or sheep a ranch will support. It is also necessary to know with assurance how many grazing animals should be placed in each pasture, drainage basin, or other unit of management and for how long a period they should remain.

UNIFORMITY OF THE STANDARD RANGE SURVEY METHODS

The requirements of a good survey method which will yield uniform forage estimates are: (1) It should be a method whereby with a reasonable amount of training a crew of men can all recognize the same density value for a given sample of vegetation; (2) the men using the method should be able consistently to estimate the relative amount of vegetation that they encounter; and (3) the estimates of the vegetation encountered should be representative of all the vegetation on the area being surveyed.

A method with these qualities can be used to show relative differences in the amount of forage on adjacent areas even when the areas are surveyed by different men. If members of a crew have the same concept of density but the method used does not sample the forage satisfactorily on a large area, estimates made by different men on adjacent range units would probably vary considerably though not consistently. If the method is capable of sampling the vegetation on a range of considerable area but the men have different density concepts, estimates of the forage on adjacent range units surveyed by different men could be expected to vary consistently, the differences depending upon the extent of variation in the density concepts of the men. Since neither of these characteristics is ideal in a range-survey method of estimating forage, the method obviously is the best which permits the least spread in density concept among the crew members and which samples the vegetation most representatively.

SIMILARITY OF DENSITY CONCEPTS

The degree to which field examiners concurred in their concept of density and forage composition when using the standard range-survey methods is demonstrated[5/] by the average size and consistency of the differences in forage estimates made by the men when employing the same field procedure and when travelling on similar routes through the range.

5/ The average difference between the number of forage acres estimated to be present by the field examiners demonstrates how far apart the men were on the average and the standard error of the difference is a measure of how consistently the men differed from each other. The ratio (t) of the average difference to the standard error of the difference was computed to determine the reliability of the average difference (tables 4 and 5).

Table 4.--Differences between forage estimates made by men 1, 2, 3, and 4 when following the same travel routes through each section

Method	Average number of forage acres per section	Average difference between men: Forage acres	Average difference between men: % of average forage acres per section	Standard error of average difference: Forage acres	Standard error of average difference: % of average forage acres per section	Ratio of average difference to its standard error (t)	Degrees of freedom
Grid procedure							
I. Reconnaissance							
Block 1	33.31	2.07	6.21	±0.797	±2.39	2.598**2/	16
Block 2	20.34	3.39	16.67	±0.988	±4.86	3.431**	16
Block 3	25.93	4.73	18.24	±0.780	±3.01	6.064**	16
Total	26.53	3.40	1/12.82	±0.497	1/±1.88	6.841**	48
II. Square-foot-density							
Block 1	18.48	3.94	21.32	±1.034	±5.60	3.810**	16
Block 2	15.00	2.60	17.33	±0.759	±5.06	3.426**	16
Block 3	19.25	.76	3.95	±1.285	±6.68	.591	16
Total	17.58	2.43	1/13.82	±0.606	1/±3.45	4.010**	48
Type-sampling procedure							
III. Reconnaissance							
Block 1	30.05	2.96	9.85	±0.940	±3.13	3.146**	16
Block 2	21.91	4.44	20.26	±0.479	±2.19	9.269**	16
Block 3	24.58	2.21	8.99	±0.553	±2.24	3.997**	16
Total	25.51	3.21	1/12.58	±0.397	1/±1.56	8.086**	48
IV. Square-foot-density							
Block 1	24.77	5.31	21.44	±0.870	±3.51	6.103**	16
Block 2	18.15	2.78	15.32	±0.511	±2.82	5.440**	16
Block 3	21.56	3.16	14.66	±0.740	±3.43	4.270**	16
Total	21.49	3.76	1/17.45	±0.417	1/±1.94	8.993**	48

1/ Test for significance between spreads in estimates between methods:

Methods compared	I & II	I & III	I & IV	II & III	II & IV	III & IV
Average difference t =	.255	.984	1.715	.327	.917	1.956*
Standard error F =	3.368**	1.452	1.065	4.891**	3.163**	1.547

2/ F's and t's with no asterisk indicate differences shown are not significant.
* Differences shown significant at low level (1 in 20).
** Differences shown significant at high level (1 in 100).

Table 5.--Differences between forage estimates made by men 2 and 5, who were paired throughout the study

Method	Average number of forage acres per section	Average difference between men: Forage acres	Average difference between men: % of average forage acres per section	Standard error of average difference: Forage acres	Standard error of average difference: % of average forage acres per section	Ratio of average difference to its standard error (t)	Degrees of freedom
Grid procedure							
I. Reconnaissance							
Block 1	36.01	1.90	5.28	±1.013	±2.81		8
Block 2	20.97	1.60	7.63	±0.887	+4.23		8
Block 3	25.88	4.37	16.89	±1.700	±6.57		8
Total	27.62	2.63	1/ 9.52	±0.723	1/ ±2.62	3.638** 2/	24
II. Square-foot-density							
Block 1	21.90	10.09	46.07	±1.807	±8.25		8
Block 2	16.10	2.48	15.40	±0.863	±5.36		8
Block 3	22.16	8.11	36.60	±0.750	±3.38		8
Total	20.05	6.89	1/ 34.36	±0.712	1/ ±3.55	9.677**	24
Type-sampling procedure							
III. Reconnaissance							
Block 1	33.96	1.46	4.30	±1.283	±3.78		8
Block 2	24.34	0.86	3.49	±0.647	±2.66		8
Block 3	26.42	1.76	6.66	±0.700	±2.65		8
Total	28.24	1.36	1/ 4.82	±0.533	1/ ±1.89	2.552**	24
IV. Square-foot-density							
Block 1	26.96	5.51	20.44	±1.397	±5.18		8
Block 2	19.45	1.32	6.79	±1.130	±5.81		8
Block 3	23.45	5.69	24.26	±0.560	±2.36		8
Total	23.29	4.17	1/ 17.90	±0.627	1/ ±2.69	2.651**	24

1/ Test for significance between spreads in estimates between methods:

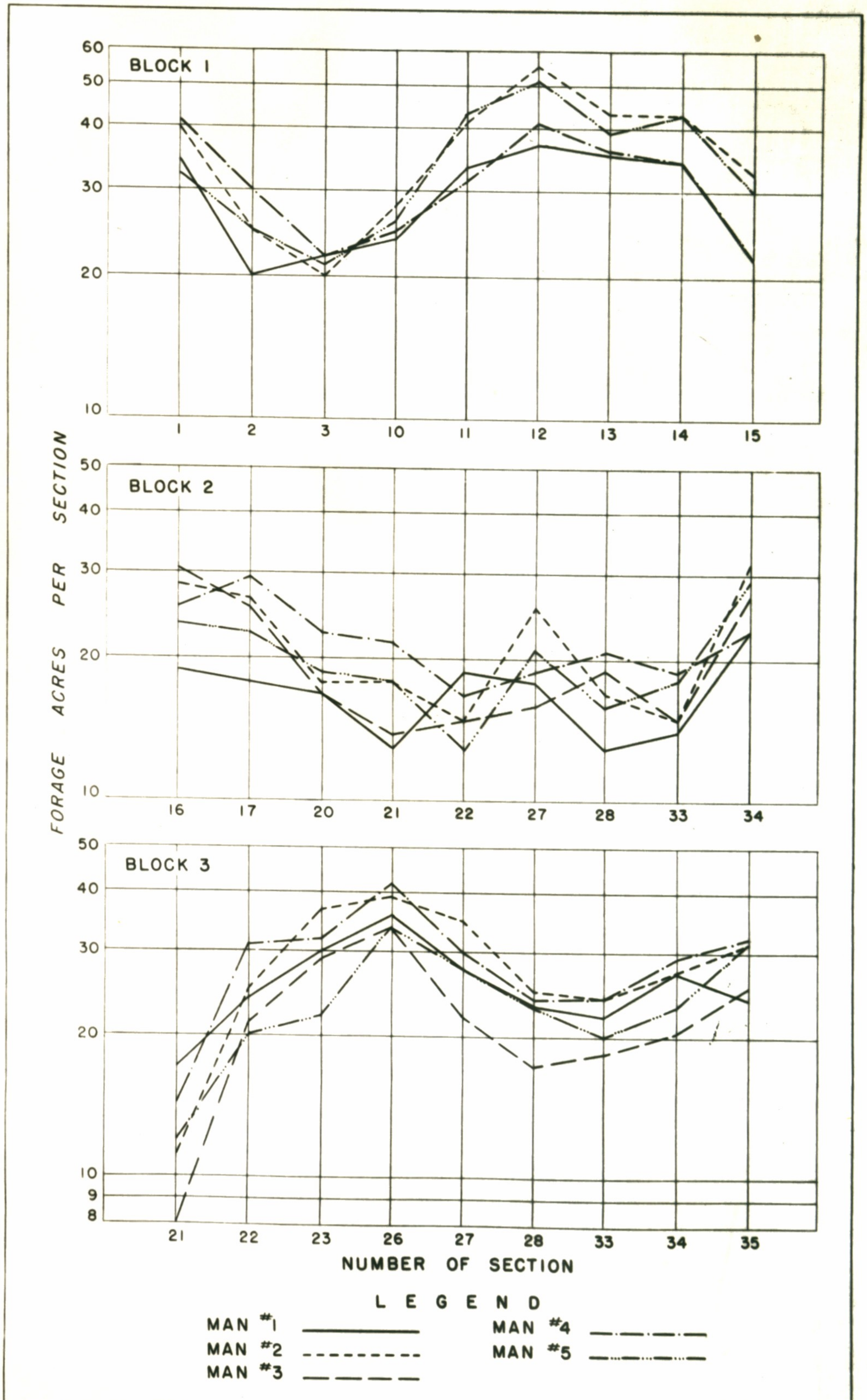
Methods compared	I & II	I & III	I & IV	II & III	II & IV	III & IV
Average difference	t = 5.633**	1.455	2.229*	7.348**	3.699**	3.976**
Standard errors	F = 1.836	1.922	1.054	3.528**	1.742	2.026*

2/ F's and t's with no asterisk indicate differences shown are not significant.
* Differences shown significant at low level (1 in 20).
** Differences shown significant at high level (1 in 100).

The field examiners were found to differ rather consistently in their estimates of the amount of forage on the range regardless of the survey method used (tables 4 and 5). For example, an examiner who estimated a greater number of forage acres than did other crew members when using a particular method was uniformly high in his individual estimates and an examiner who estimated relatively low was equally consistent. This trend is demonstrated by figures 6, 7, 8, and 9, which show graphically the forage estimates made by individual men on each section. While some fluctuation in rank is noted on individual sections, on the average the forage estimates of each man maintained approximately the same position with respect to those of the remainder of the crew throughout each block of 9 sections. For example, in using the type-sampling reconnaissance method, man 5 estimated that there were more forage acres than did man 3 on 26 of the 27 sections surveyed. Likewise, man 1 estimated less forage than man 5 on all 27 sections when using the grid square-foot-density method and on 26 out of 27 sections when using the type-sampling square-foot-density method. On the average the estimates of each field examiner maintained approximately the same place in relation to those of the remainder of the crew, regardless of the survey method in use. Notable exceptions are man 5, who usually estimated higher than the average of the crew when using both the square-foot-density and the reconnaissance methods, but who estimated lower than the crew average when surveying block 3 by the grid reconnaissance method; and man 2, whose estimates usually were lower than the crew mean when using the square-foot-density method, but were higher by the reconnaissance method.

I

FIGURE 6

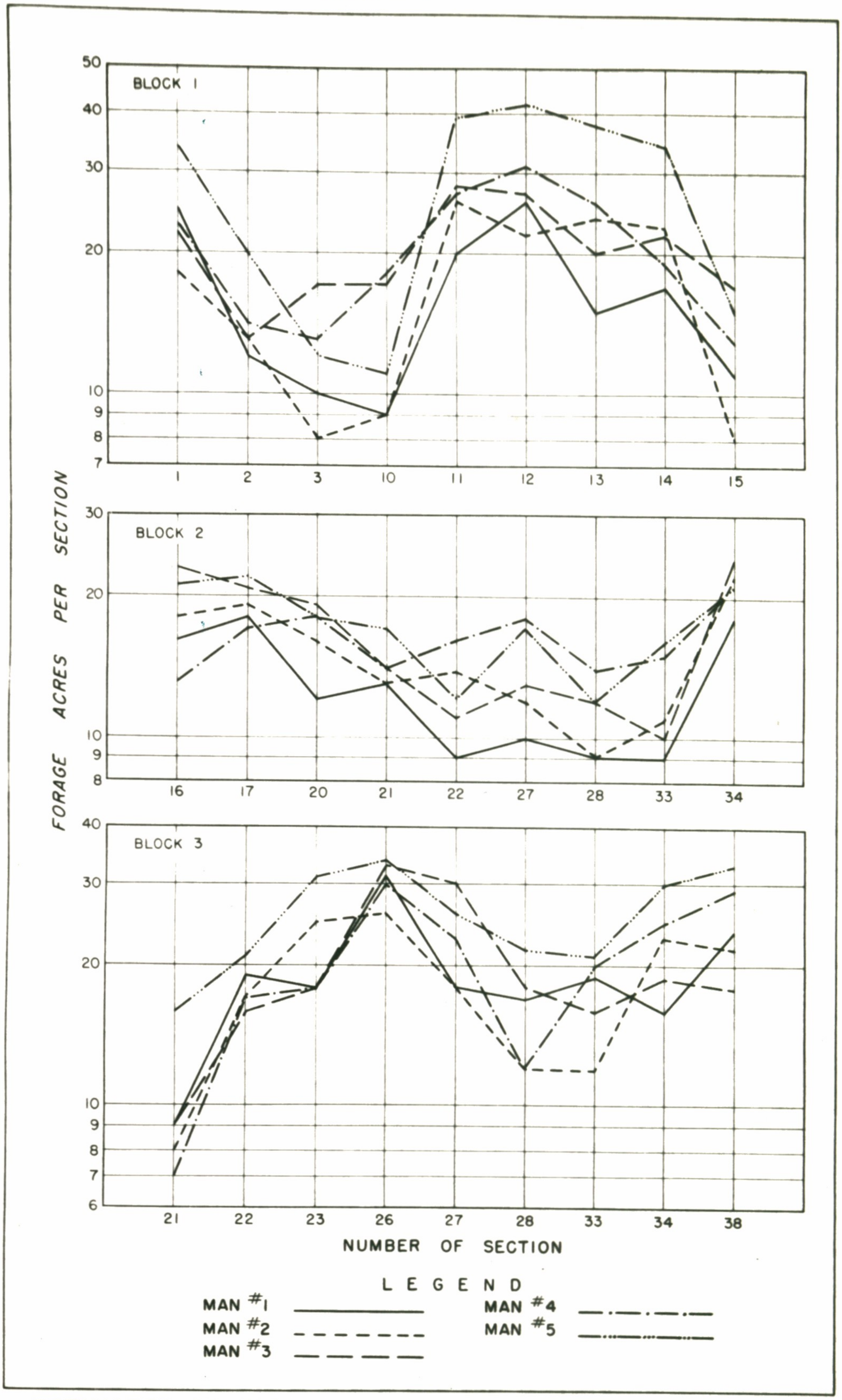


ESTIMATES OF FORAGE MADE USING THE STRIP PROCEDURE OF MAPPING AND THE RECONNAISSANCE METHOD OF SAMPLING THE VEGETATION.

U.S.F.S. W.O., 1940

M. Littman '40 - April

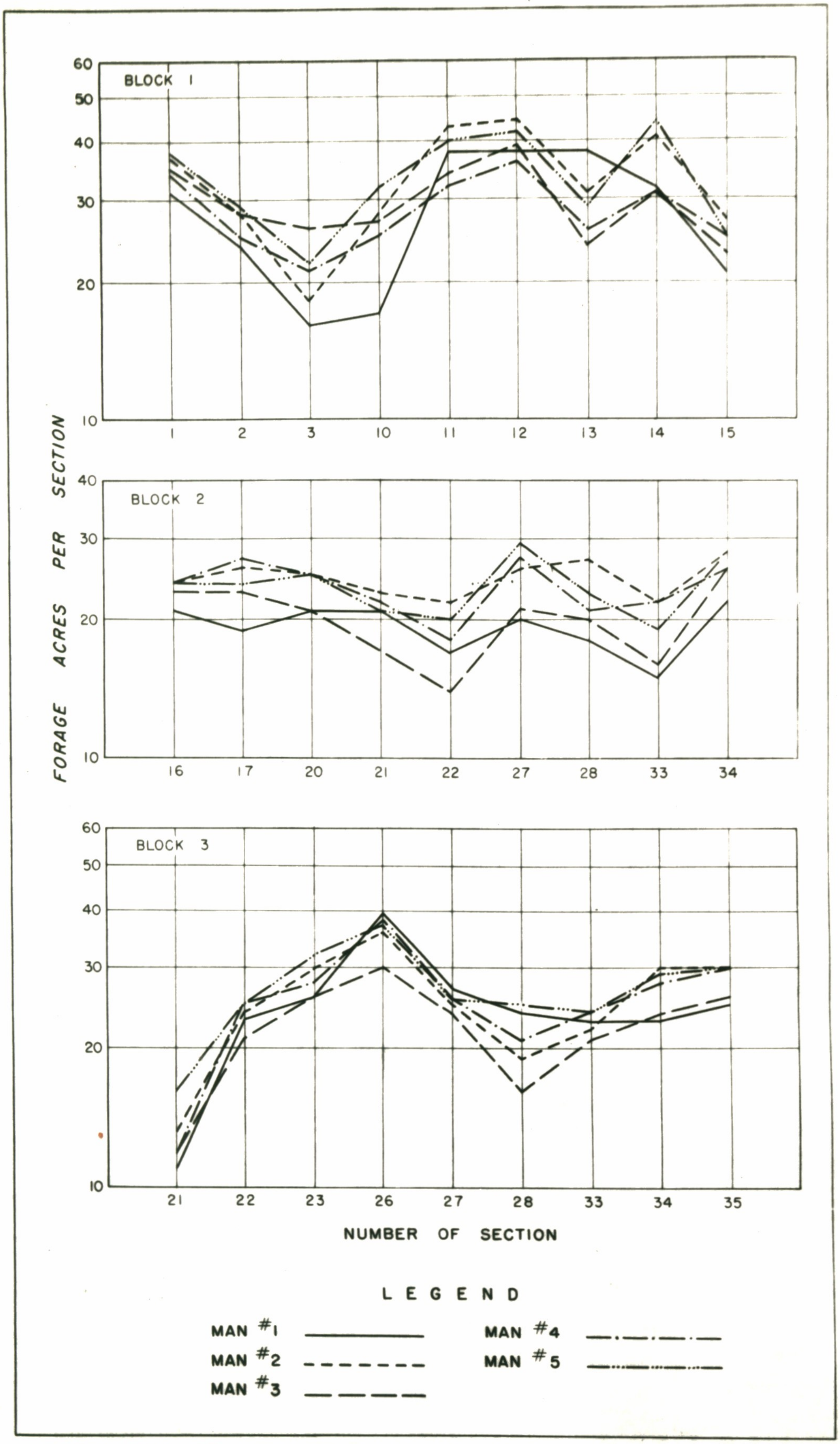
FIGURE 7



ESTIMATES OF FORAGE MADE USING THE STRIP PROCEDURE OF MAPPING AND THE SQUARE-FOOT DENSITY METHOD OF SAMPLING THE VEGETATION.

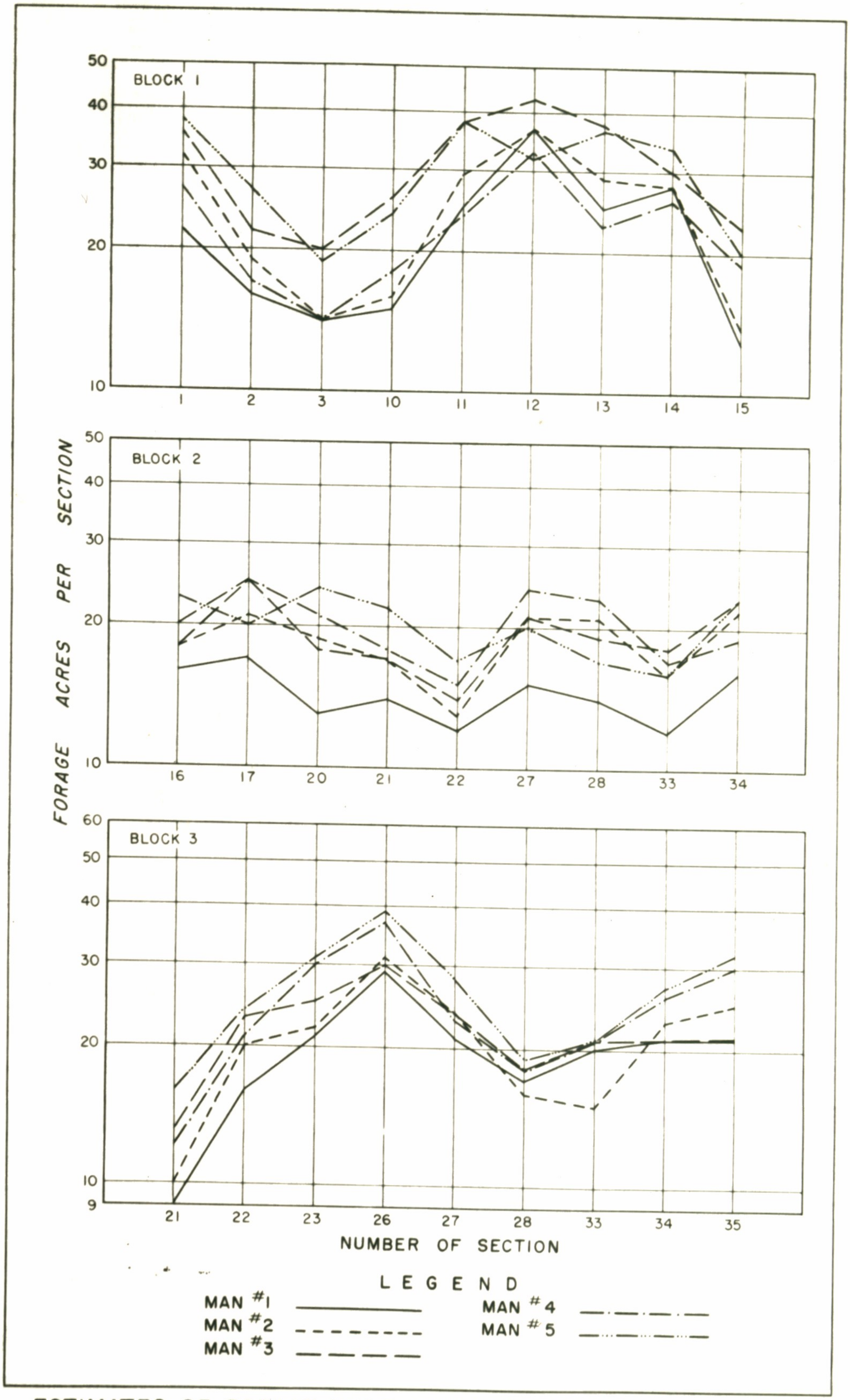
U.S.F.S. W.O.,1940

FIGURE 8



ESTIMATES OF FORAGE MADE USING THE TYPE SAMPLING PROCEDURE OF MAPPING AND THE RECONNAISSANCE METHOD OF SAMPLING THE VEGETATION.

Figure 9



ESTIMATES OF FORAGE MADE USING TYPE SAMPLING PROCEDURE OF MAPPING AND THE SQUARE-FOOT DENSITY METHOD OF SAMPLING THE VEGETATION.

USFS W.O., 1940

Comparisons of the average difference[6] between forage estimates made by field examiners sampling the same forage (i.e., following the same route of travel through each section) showed that on the average the field examiners were closer together in their forage estimates when employing the reconnaissance method than when using the square-foot-density method. The average spread between forage-acre estimates made under these conditions by men 1, 2, 3, and 4 was 3.40 forage acres for the grid procedure and 3.21 forage acres for the type-sampling procedure when using the reconnaissance method (table 4). As the average number of forage acres per section estimated by the four men was 26.53 forage acres for the grid procedure and 25.51 forage acres for the type-sampling procedure, the average difference between the estimates was 12.82 percent and 12.58 percent respectively. Similar tests of the square-foot-density method indicated a spread of 2.43 forage acres for the grid procedure and 3.76 for type sampling, which amounted to respective differences of 13.83 percent and 17.45 percent. Similar results were obtained from the separate comparison of the average difference between forage-acre estimates made by men 2 and 5, who were paired throughout the study. The average difference between estimates made by these two men was 4.82 percent for the type-sampling reconnaissance and 9.82 percent for the grid reconnaissance

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6/ To compare the relative uniformity of forage estimates by the different methods the average difference in forage acres between estimates of men was converted to the percent of the mean forage acreage per section. This was necessary because a forage acre by one method of estimating density represents a different amount of forage than does a forage acre by another method. For example, a forage acre by the grid square-foot-density method which gave an average of 18.76 forage acres per section represents for this study 1.424 times as much forage as does a forage acre by the grid reconnaissance method. Therefore an average spread in estimates of 1 forage acre per section represents a difference of 5.33 percent by the former method and 3.74 percent by the latter method.

method, which is considerably less in both cases than their average differences of 17.90 percent for the type-sampling procedure and 34.36 percent for the grid procedure when using the square-foot-density method (table 5).

Analysis of relative spread in forage estimates of the four men (table 4) indicates that significance[7] can be demonstrated on which to base the conclusion that the men were closer together in their estimates when using the type-sampling reconnaissance method than they were with the type-sampling square-foot-density method. The four men and men 2 and 5 (table 5) invariably showed a smaller average spread in their forage estimates when made by the reconnaissance method, using either mapping procedure, than was the case for the square-foot-density method. Moreover, in the case of men 2 and 5, the smaller spreads in their forage estimates when made by the reconnaissance method proved statistically significant. The summation of these facts leads to the conclusion that field examiners consistently tend to be closer together in their forage estimates, and therefore in their concept of density, when using the reconnaissance method of making range surveys.

Field Arrangement to Minimize Consistent Spread in Forage Estimates

As it is desirable to obtain forage estimates on a range survey that are as uniform as possible, consistent differences between field examiners in the way they estimate forage should be given careful consideration in planning the field work. If the men are consistent in

7/ "Significance" as used in this report means that odds are 19 in 20 or greater that the results demonstrated are not caused by sampling alone.

their estimates but estimate forage values at different levels, the arrangement of the field work will affect the accuracy obtained from the survey. In field procedure it has often been the practice to assign a unit of range several sections in size to a single field examiner. This area is usually a separate watershed or a mangement unit. The advantages of this procedure are: (1) It allows the field examiner to work more efficiently by planning his work ahead; and (2) a single field examiner will have seen the whole area and should be in a better position to interpret management problems. With this field arrangement, all the forage within the block is estimated by a single man and will show more or less feed than exists on the block in relation to adjacent units, depending on whether the man estimates density higher or lower than the men making estimates on adjacent units. By following this practice, good estimates of the total forage on several units would be obtained, but the distribution of the forage among the units would not be evaluated properly.

To insure obtaining range survey data that will give the most dependable basis for distribution of livestock on a grazing allotment, field work should be so planned that estimates by as many examiners as possible are obtained within each subdivision of the allotment. Such an arrangement should result in the greatest compensation of spread in estimates and, therefore, should give the best figures both for stocking and for distribution purposes.

CONSISTENCY AND REPRESENTATIVENESS OF FORAGE ESTIMATES

A good range-survey method not only should be of such a nature that it permits a uniform concept of density to be maintained between a crew of examiners, but also it should provide: (1) That this concept be applied effectively and constantly in everyday field work as the examiners estimate forage values individually on range areas; and (2) that the portions of the range area that the examiners cover in their survey, and on which the forage estimates are based, be representative of the entire range area for which the estimates are designed. It is possible, for example, that a highly intensive method may be ideal from the standpoint of a crew being able to recognize the same density unit and, at the same time, be impractical for use in the extensive manner required of range surveys. To be suitable for use on range areas, therefore, a range-survey method must: (1) Furnish a sound estimate of forage encountered while traversing through a range area; and (2) feasibly permit travel routes of such nature that the forage encountered is representative of the area in its entirety. These two features, combined, govern the inherent consistency of a survey method in obtaining uniform estimates of relative forage values.

These two criteria of consistency of range-survey methods were studied by comparing the standard error of the difference between forage estimates of the examiners when paired (sampling the same forage by following the same route of travel through each section) and when unpaired (sampling different forage by going at right angles to each other through each section). For example, with the type-sampling reconnaissance method for block 1, two men (men 1 and 3) went in an east-west

direction and two men (men 2 and 4) went north and south. The standard error of the difference between estimates made by men 1 and 3 and men 2 and 4 shows how consistently the field examiners estimated the forage they saw when traversing through the area. Similarly, the standard error of the difference between forage estimates made by men 1 and 2 and men 3 and 4, who traversed the area at right angles to each other through each section, shows the degree of consistency in estimating forage encountered but also injects the degree of variation that results from not encountering the same forage because of traveling in different directions. A similar comparison can be made between men 1 and 4 and men 3 and 2. The average of these two sets of comparisons gives the best estimate of the standard error of the difference between estimates made by the men when going at right angles to each other. By comparing these results with the standard error of the difference arrived at for forage estimates of men going in the same direction of travel through each section, it is possible to determine if the direction of travel materially affected the forage estimates. Such comparisons permit drawing conclusions on how well estimates made by a range-survey method of forage encountered represent the entire forage of the area being surveyed.

Square-Foot-Density Method

Estimates of the relative amount of forage encountered when made by the type-sampling square-foot-density method proved to be more consistent than those made by the grid square-foot-density method. The standard error of the difference between forage estimates made by men 1, 2, 3, and 4 was ±3.45 percent for the grid procedure, which is considerably larger

than that of ±1.94 percent for the type-sampling procedure (table 4). The comparison between estimates by men 2 and 5 showed the same trend, the standard error of the difference being ±3.55 percent for the grid procedure and ±2.69 percent for the type-sampling procedure. Theoretically the consistency of forage estimates by a sampling method such as the square-foot-density increases as the number of plots increases, and much of the difference between the consistency of the two procedures must result, therefore, from the greater number of plots used in the type-sampling procedure. An average of 36 plots per section was used for the type-sampling procedure as compared to 20 plots per section by the grid procedure. If an average of 36 plots instead of 20 plots per section had been used in the grid procedure, the standard error of the difference between estimates would have been expected to be approximately ±2.57 percent for differences between men 1, 2, 3, and 4 and ±2.65 percent for the comparison between men 2 and 5. Therefore, it is evident that the increased consistency of estimates by men 2 and 5 shown for the type-sampling procedure was no more than should have resulted from the grid procedure had 36 plots per section been used instead of 20. On the other hand, for the comparison between estimates made by men 1, 2, 3, and 4 when using the type-sampling procedure, the estimates were more consistent than would be expected by using 36 plots per section by the grid procedure, the theoretical standard error of ±2.57 percent for the grid procedure being significantly larger than the standard error of ±1.94 percent for the type-sampling procedure. This analysis is interpreted to indicate the larger number of plots taken when using the type-sampling square-foot-density method to be a major factor in increasing the consistency of

forage estimates, but that its superiority over the grid square-foot-density method in this respect also is because of the manner in which the plots are distributed within subtypes and the more refined mapping procedure that is used.

The direction of travel through each section did not affect the forage estimates when using the square-foot-density method. For the grid procedure the average difference between the men in their forage estimates was 13.82 percent when the same routes of travel were followed and 10.30 percent when the men went at right angles to each other (table 6). For the same procedure the standard error of the difference between the men was ±3.45 percent when the same routes of travel were followed and ±3.37 percent when the men traveled at right angles to each other. The ratios between these average differences and their standard errors were not of sufficient size to be considered important (table 6). As similar results were shown by the type-sampling procedure it can be concluded that forage estimates obtained by the square-foot-density method from plots that are arranged either in a grid pattern or in separate transects through each subtype are as representative of the forage on the range as a whole as they are of the forage encountered.

Reconnaissance Method

Field examiners when employing the type-sampling reconnaissance method were very little, if any, more consistent in estimating the relative amount of forage encountered than they were when using the grid reconnaissance method. While the standard errors of the difference between forage estimates made using the type-sampling method (table 4) of ±1.56 percent and ±1.89 percent for the comparison between men 1, 2,

Table 6.--Comparison of differences between forage estimates made by four men when following the same travel routes through each section and when following travel routes at right angles to each other

Method	Average difference between men		Standard error of average difference between men		t between average differences	F between standard errors
	Following same routes	Traveling at right angles	Following same routes	Traveling at right angles		
Grid procedure						
I. Reconnaissance	12.82	14.40	±1.88	±2.53	1/ .502	1/ 1.8110*
II. Square-foot-density	13.82	10.30	±3.45	±3.37	.730	1.048
Type-sampling procedure						
III. Reconnaissance	12.58	8.98	±1.56	±2.21	1.328	2.007**
IV. Square-foot-density	17.45	15.73	±1.94	±1.85	.642	1.0997

1/ F's and t's with no asterisk indicate differences shown are not significant.
* Differences shown significant at low level (1 in 20).
** Differences shown significant at high level (1 in 100).

3, and 4 and men 2 and 5, respectively, both are actually smaller than the standard errors of ±1.88 percent and ±2.62 percent for the same comparisons for estimates by the grid reconnaissance method, statistically the differences between them were not significant. Therefore, it can be concluded that the forage encountered by the field examiner while traversing through the range was sampled equally well by either procedure.

The direction of travel affected the forage estimates obtained by the reconnaissance method. Although the average differences between the men in their forage estimates were not materially affected by the direction of travel (table 6) the consistency of estimates was much better between the men when following the same route of travel than when going at right angles to each other through the range. For the grid procedure the standard error of the difference between the men was ±1.88 percent when following the same routes of travel, which is significantly less than the standard error of ±2.53 percent for estimates made by men going at right angles to each other. This same significant trend was shown to exist in the type-sampling procedure for which the standard error of the difference between men following the same routes of travel was ±1.56 percent compared to that of ±2.21 percent for men going through the range at right angles to each other. It is evident, therefore, that the men when using the reconnaissance method made good estimates of the forage they saw en route but that they did not always see a sufficient amount of the range area to give a forage estimate that was wholly representative.

Reconnaissance Versus Square-Foot-Density

Forage estimates made by the grid square-foot-density method, as evidenced by the magnitude of the standard errors (table 6), were less representative of forage on the range than those made by either the type-sampling reconnaissance or the grid reconnaissance method. On the other hand, forage estimates made by the type-sampling square-foot-density method were as representative as those made by the type-sampling reconnaissance method and were somewhat more representative than those made by the grid reconnaissance method.

The type-sampling reconnaissance method gave somewhat more consistent estimates of the forage encountered along the route of travel than did the type-sampling square-foot-density method. The standard error of the difference between men 2 and 5, who followed similar travel routes throughout the study, was ±1.89 percent for the reconnaissance method and ±2.69 percent for the square-foot-density method, the difference between these being significant (table 5). For the same comparison between men 1, 2, 3, and 4, the standard error of the difference was also smaller for the reconnaissance method (±1.56 percent) than for the square-foot-density method (±1.94 percent), but the probability that differences as large as that shown between the methods might result from sampling alone was too great to attribute significance to it (table 4). However, the two comparisons with the same trends, one showing significance and the other just below the level of significance, lead to the conclusion that the reconnaissance method is more likely to give consistent estimates of forage encountered than is the square-foot-density method. This conclusion is substantiated by the comparisons of forage estimates on the two transects of

permanent plots previously mentioned (table 2). Analysis of forage estimates on these plots made at weekly intervals throughout the 12-week period showed that an error[8] of 9.9 percent can be expected when estimating average forage factor on three .15-acre plots by the reconnaissance method, compared with an expected error of 19.1 percent on nine 100-square-foot plots on which forage estimates are made by the square-foot-density method. As these forage estimates were made on the same plots at weekly intervals, the element of sampling the vegetation is eliminated and the error can be attributed solely to that of estimating the density of the same vegetation.

While the type-sampling reconnaissance method may give better estimates of the forage encountered on the route of travel than will the type-sampling square-foot-density method, this advantage is offset by the fact that the estimates of the forage encountered using the former method did not always depict conditions typical of those on the whole area whereas the estimates from the impersonally selected plots used in the latter method were as representative of all the forage as they were of the forage encountered. The standard error of the difference between forage estimates made by the men traversing at right angles to each other (table 6) was ±1.85 percent for the type-sampling square-foot-density method, compared with ±2.21 percent for the type-sampling reconnaissance method. However, the difference in consistency between estimates of examiners travelling at right angles and using the type-sampling reconnaissance method was not

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8/ In table 2 the mean square of the error for estimates of all vegetation (forage factor) is shown as .00007577 for the reconnaissance method and .00015766 for the square-foot-density method. The square roots of these give sampling errors of ±.008704 forage factor for the reconnaissance method and ±.01256 forage factor for the square-foot-density method. These are ±9.9 percent and ±19.1 percent, respectively, of the average forage factor estimated to be present on the plots by each method.

significantly greater (F = 1.297) than when they used the type-sampling square-foot-density method and travelled in the same direction. It is evident, therefore, that the field examiner makes a better write-up of the forage he sees using the reconnaissance method than he obtains from the square-foot-density plots, but the latter method of sampling gives just as representative estimates of all the forage on the range. In using the square-foot-density method where the plots were distributed mechanically, some parts of the range apparently were sampled which were overlooked when using the reconnaissance method. Therefore, the accuracy[9] of the reconnaissance method can be improved by making a more thorough examination of each subtype, whereas the accuracy of the square-foot-density method can be improved by increasing the number of plots taken in each subtype. As the standard range surveys were used in this study, however, it can be stated that there is little to choose between the type-sampling procedures of the reconnaissance and the square-foot-density methods in obtaining representative estimates of the amount of forage on a range area.

9/ The term "accuracy" is used to denote uniformity of results between field examiners or crews rather than exactness of forage estimates. Range survey data that uniformly represent existing forage conditions are deemed usable and dependable. Such data are termed accurate since, if grazing capacities are estimated uniformly lower or higher than the actual, the estimates may be corrected by raising or lowering the forage-acre requirement to what is judged to be the correct figure. Moreover, with uniformity in estimates, the relation of forage values on different portions of the range is correctly depicted.

RATINGS OF THE RANGE SURVEY METHODS FROM THE STANDPOINT OF FORAGE ESTIMATES

The separate tests to study the spread and consistency of forage estimates have revealed the following characteristics of the standard range-survey methods:

(1) By the reconnaissance methods field examiners were closer together in their density estimates than by the square-foot-density methods.

(2) The grid square-foot-density method using 20 plots per section to sample the vegetation gave forage estimates that were less consistent than those made by other methods.

(3) When following the same travel route, examiners using the type-sampling reconnaissance method were somewhat more consistent in their forage estimates than when the type-sampling square-foot-density method was used.

(4) In both the grid and the type-sampling procedures of the reconnaissance method, the route of travel through the range affected the consistency of forage estimates.

(5) With the type-sampling reconnaissance method, forage estimates made by men when going at right angles to each other were not so inconsistent as to be significantly poorer than forage estimates made by the type-sampling procedure of the square-foot-density method.

Interpretation of the separate tests of average spread and consistency affords an opportunity to rate the individual range-survey methods from the standpoint of their effectiveness in obtaining dependable forage estimates. The fact that the average spread of estimates was less for

both procedures of the reconnaissance method than for the square-foot-density methods indicates that a more uniform density concept is maintained by using the former method of surveying range forage. The high degree of inconsistency found in the grid square-foot-density method when conducted at an intensity of 20 plots per section so materially affected forage estimates that this survey method is rated lowest in dependability. Dependable estimates of forage encountered were obtained by the grid reconnaissance method, but the necessity of maintaining a more or less fixed travel route for mapping purposes and, therefore, seeing an insufficient sample of the forage on individual subtypes resulted in obtaining forage estimates that were not always representative of the forage on the area as a whole. By using the type-sampling procedure through the aid of aerial photographs, sufficient forage was seen on subtypes by either the square-foot-density or the reconnaissance method so that the forage estimates were satisfactorily representative. However, since the average spread in forage estimates obtained by the type-sampling reconnaissance method was consistently less than was the case with the type-sampling square-foot-density method, its results were judged superior. Based upon this interpretation of the analyses of the standard methods from the standpoint of forage estimates, the type-sampling reconnaissance method is considered best, the type-sampling square-foot-density method second best, the grid reconnaissance method third, and the grid square-foot-density method poorest.

UNIFORMITY OF FORAGE ESTIMATES TO BE EXPECTED IN FIELD APPLICATION OF THE RANGE SURVEY METHODS

The uniformity of a range-survey method depends not only on the degree to which the field examiners maintain a uniform density concept, use the concept effectively to estimate the forage encountered, and sample each area to assure representativeness of the forage estimate; it also depends on the combined effect of these attributes on results obtained from field application of the method. The foregoing section on uniformity has dealt with the comparative spread and with the relative consistency of forage estimates made by individual field examiners covering the same range unit with a range-survey method. The object of this section is to portray for the four survey methods the combined effect of these spreads and consistencies when each of the field examiners surveys a different part of the range in the manner that is standard field practice in range surveying. Such a comparison of range-survey methods gives to the person interested in application of results a quantitative picture of how accurately relative grazing capacity may be estimated by a standard range-survey method when it is applied with a crew similar in capability to the crew used in this study.

Uniformity on a range survey involves the differences between the men as well as the accuracy of the method used. In the analysis (table 7) for each method the man differences are expressed by the mean squares between man means and the accuracy of the method by the man-section interaction (error). The former is a measure of the difference between the forage estimates of the men and the latter is a measure of the error of one man estimating forage on a section. From these two sources of variation the

Table 7.--Variance analysis for each of the range-survey methods of all forage estimates made by the field examiners on the 27 sections

Source of variation	Reconnaissance			Square-foot-density		
	Degrees of freedom	Mean square	F	Degrees of freedom	Mean square	F
Grid procedure						
Between man means	3	113.95	9.264** 1/	4	238.28	21.256**
Between block means	2	1510.95		2	368.61	
Between section means	24	182.91		24	165.42	
Interaction						
Man x block	6	21.58	1.758	8	25.08	2.095
Man x section (error)	72	12.30		96	11.21	
Type-sampling procedure						
Between man means	4	115.97	17.625**	4	188.58	33.026**
Between block means	2	880.63		2	588.13	
Between section means	24	151.04		24	155.64	
Interaction						
Man x block	8	19.93	3.029**	8	45.89	8.037**
Man x section (error)	96	6.58		96	5.71	

1/ F with no asterisk indicates differences shown are not significant.
* Differences significant at low level (1 in 20).
** Differences shown are significant at high level (1 in 100).

accuracy (standard deviation) of forage estimates on range areas one square mile in size that may be expected from a range-survey crew of capabilities similar to those of the crew used in the experiment was computed[10] and is shown in table 8.

On the basis of a range survey where several men work together as a crew, each man estimating the forage on different parts of the range, the type-sampling reconnaissance method was shown to be the most accurate with a standard deviation of forage estimates on a single section of ±3.41 forage acres or ±13.05 percent of the average number of forage acres per section (table 8). Forage estimates by the grid reconnaissance and type-sampling square-foot-density methods were of nearly equal uniformity with standard deviations of ±15.02 percent and ±15.85 percent respectively. Forage estimates by the grid square-foot-density method were least accurate, with a standard deviation of ±23.56 percent. These standard deviations indicate the limits of accuracy within which relative forage values of areas one section in size can be expected to be estimated by crew members with capabilities similar to those of the men used in the experiment. For example, using the type-sampling reconnaissance method on a range survey, the majority of forage estimates on single sections by a crew member can be expected to vary not more than 13.05 percent from

10/ The mean squares between men are composed of variation arising from two sources; variance between men (A) and sampling error (man x section interaction) (B). The expected variation between estimates by two men on a single section is a combination of both variables A and B and the standard deviation of estimates of the men on a single section = $\pm\sqrt{A + B}$. Approximately two-thirds of the estimates would be expected to fall within one standard deviation of the mean, and 95 percent of the estimates would probably fall within two times the standard deviation.

Table 8.--Accuracy[1] of forage estimates that may be expected on a regular range survey made by a crew of capabilities similar to those of the crew used in the experiment

Method	Average number of forage acres per section	Standard deviation of forage estimates							
		On 27 sections		On 9 sections		On 3 sections		On 1 section	
		Forage acres per section	% of mean forage acres per section	Forage acres per section	% of mean forage acres per section	Forage acres per section	% of mean forage acres per section	Forage acres per section	% of mean forage acres per section
Grid procedure									
I. Reconnaissance[2]	26.71	±0.77	±2.88	±1.34	±5.02	±2.32	±8.68	±4.01	±15.02
II. Square-foot-density[3]	18.76	±0.85	±4.53	±1.47	±7.84	±2.55	±13.59	±4.42	±23.56
Type-sampling procedure									
III. Reconnaissance[3]	26.14	±0.66	±2.52	±1.14	±4.36	±1.97	±7.54	±3.41	±13.05
IV. Square-foot-density[3]	22.27	±0.68	±3.05	±1.18	±5.30	±2.04	±9.16	±3.53	±15.85

1/ See footnote 9 of the text.
2/ Based upon men 1, 2, 4, and 5.
3/ Based upon men 1, 2, 3, 4, and 5.

the values that would be obtained were the entire crew to estimate each section. With the type-sampling square-foot-density method the majority of forage estimates made by a crew member can be expected to vary not more than 15.85 percent from uniformity. Table 8 also shows the extent of variations that can be expected in forage estimates on areas 3 sections,[11] 9 sections, and 27 sections in size.

There are many factors, other than the amount of forage, that affect the number of animals that properly can be grazed on a range. It follows that, even though the exact amount of forage can be measured, grazing capacity may not be accurately determined. The forage-acre requirement and the proper-use factor are approximate measurements. Likewise, all of the forage present may not or should not be used because of livestock habits, range terrain, or range condition. The estimate of grazing capacity made from the range survey can be considered only as the best estimate available when placing a range under management and should be regarded as subject to future adjustment when knowledge of the range and its use is increased through subsequent inspection. While it is desirable to know as nearly as possible how much forage there is on a range, small adjustments in grazing-capacity estimates readily can be handled in revision of the management plan as needed. The fact that forage estimates are subject to personal and sampling error should be recognized when using the range-survey data.

Forage estimates such as were obtained in this study by the

11/ Variations of forage estimates on more than one section were computed from the standard deviation by use of the formula

$$S_{\bar{x}} = \frac{S_x}{\sqrt{n}}$$

reconnaissance method using either mapping procedure, or by the type-sampling square-foot-density method, are considered sufficiently dependable to fulfill the requirements of most range-survey projects on national forests or similar ranges. Estimates that may be expected to be within 13 to 16 percent of the relative amount of forage on areas one section in size are considered to be satisfactory for purposes of planning effective livestock distribution within grazing allotments. Moreover, estimates that may be expected to depict the forage values on range areas not smaller than 3 sections within 10 percent are sufficiently reliable to warrant their use as a basis for determining the proper period and intensity of grazing for ranges that represent units on which grazing is rotated in managing an allotment or a ranch. Even the grid square-foot-density method employing 20 plots per section, which is not considered to be satisfactory for determining forage values of small areas, gives sufficiently dependable forage estimates on areas 27 sections in size to warrant the conclusion that through its use on range surveys the total number of livestock which properly may be grazed on a range allotment or ranch can be determined satisfactorily.

UNIFORMITY OF FORAGE ESTIMATES ON SUBTYPES

The subtype is considered to be an indivisible unit in practical range forage management. It represents to the range survey examiner an area on which the vegetation and range conditions are sufficiently similar to be considered an entity and yet are different enough from conditions on the surrounding range to warrant separation. Estimates of the amount of forage are, therefore, made on each subtype and the forage value of a

section, watershed, pasture, or other grazing unit is determined by adding the amounts of forage that are found to exist on the included subtypes. The uniformity of the forage estimates on grazing units, therefore, depends upon the accuracy of the forage estimates for individual subtypes.

SQUARE-FOOT-DENSITY METHOD

Results of analysis of forage estimates made by the five men on subtypes[12] show that when using the square-foot-density method to estimate the vegetation, the average variation of an examiner's forage estimates from the crew mean was correlated with the area, magnitude of the forage factor, and the number of forage acres on the subtypes (table 9). Figure 10, that presents the relation of the average deviation from uniformity of forage estimates to area of the subtype and average forage factor, shows forage estimates made by the square-foot-density method to be more accurate for dense vegetation than for sparse vegetation. For example, on a subtype 300 acres in area with an average forage factor of .010, the average deviation of forage estimates from the crew mean is expected to be 1.45 forage acres, 48 percent of the three forage acres on the subtype. This is a much greater variation than the 13 percent average deviation that the data indicate is expected from estimates of a 300-acre subtype containing an average forage factor of .050. The greater error in estimating sparsely vegetated subtypes undoubtedly is due to the relatively large interval used in estimating density on a 100-square-foot plot, which

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12/ When employing the type-sampling procedure for both the reconnaissance and square-foot-density methods all men estimated forage within the same subtype boundaries, which permitted direct comparisons between individual forage estimates on subtypes.

Table 9.--Relationship for each range-survey method between spread in forage estimates on a subtype and (1) area of the subtype in acres, (2) average forage factor of the subtype, and (3) number of forage acres

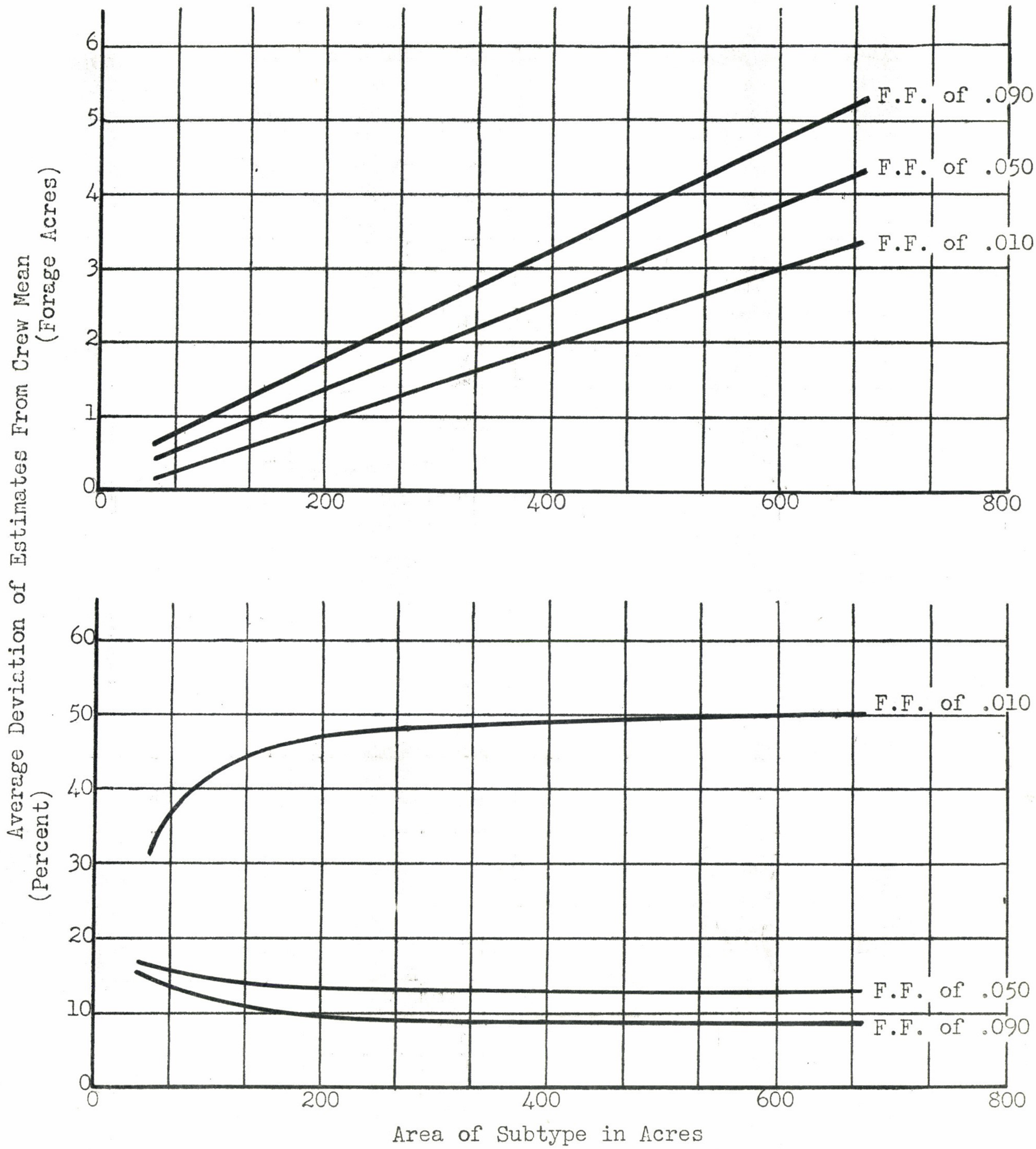
Method	Correlation coefficient	Regression coefficient		
		Area of subtype	Average forage factor	Total forage acres
Reconnaissance 1/	.954** 3/	-.000347	-2.122651	.122078**
Reconnaissance 2/	.955**			.115193**
Square-foot-density 1/	.966**	.004892**	4.751530**	.028310*

1/ Multiple correlation.

2/ Simple correlation.

3/ Coefficients with no asterisk indicate relationship between the variables is not significant.
* Relationship between variables is significant at low level (1 in 20).
** Relationship between variables is significant at high level (1 in 100).

FIGURE 10.--EFFECT OF AREA AND AVERAGE FORAGE FACTOR OF SUBTYPES ON THE VARIATION OF FORAGE ESTIMATES BY THE SQUARE-FOOT-DENSITY METHOD



in standard range-survey practice is 0.5 square foot. Using this density interval, vegetation that covers three-fourths of a square foot of ground on a 100-square-foot plot ordinarily would be estimated correctly either as 0.5 square foot or as 1.0 square foot. However, the 0.5 square foot estimate is 33 percent lower and the 1.0 square foot estimate is 33 percent higher than the actual density. Theoretically, with several plots used to sample the vegetation these differences should average out. Actually, however, with field examiners having somewhat different density concepts, one would tend more often to record the lower density value, whereas another usually would raise it. This gives opportunity for wide percentage spreads in estimates that are of minor importance when they concern the secondary species on high density types, but which become major in estimating the value of range on which sparse vegetation furnishes the main forage. When estimating density on plots in the latter type of range a smaller density interval should be used.

Figure 10 also indicates forage estimates made by the square-foot-density method to be most accurate on subtypes that contain high densities of palatable forage such as those with average forage factors of .090. Subtypes of higher forage value, such as densely vegetated meadows, were not available in sufficient quantity to study. However, the authors have experienced considerable difficulty in training men to estimate meadow vegetation by the square-foot-density method, since it is difficult to count up high densities on 100-square-foot plots with such a small unit as a square foot. Also, the sod vegetation and the bunched vegetation of meadows usually are so intermixed that it is difficult to separate species ocularly and to obtain checks on density by means of a square-foot wire frame. In view of

these known, practical difficulties, it is uncertain that the trend toward increased accuracy with increasing density shown in figure 10 applies to the denser meadow types.

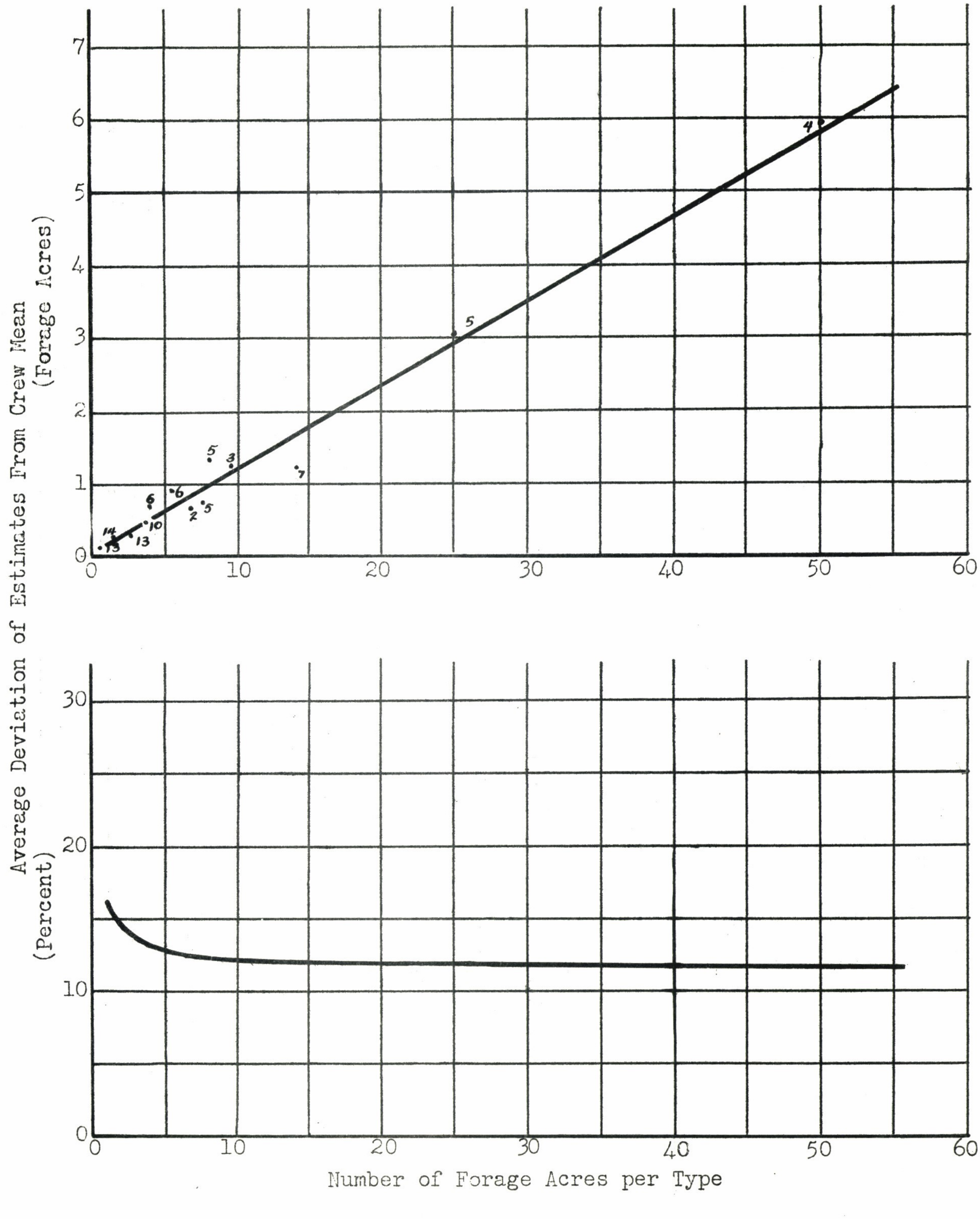
Except for very sparse vegetation, forage estimates tend to be more accurate for subtypes larger than 200 acres than for those smaller than 200 acres. This undoubtedly results from the greater number of plots used to sample the larger types. Forage estimates on sparsely vegetated subtypes, however, probably contain such a high percentage of error per plot that the effect of replication is nullified.

RECONNAISSANCE METHOD

Contrasted with the square-foot-density method, for which the spread in forage estimates tends to vary with the area, average forage factor, and number of forage acres on the subtype, is the reconnaissance method, for which no net relationship was found to exist between the size or average forage factor of the subtype and the spread in forage estimates (table 9). For the reconnaissance method, the average deviation of estimates is correlated directly with the number of forage acres on the area. Figure 11, that presents the relation of the average deviation from uniformity of forage estimates to the number of forage acres, indicates that about the same variation in forage estimates can be expected for subtypes containing 10 or more forage acres. For subtypes containing less forage a somewhat greater percentage deviation can be expected, averaging 12.5 percent for subtypes containing 5 forage acres and 13.5 percent for subtypes containing 3 forage acres.

The absence of a net relationship between area of subtypes and

FIGURE 11.--EFFECT OF NUMBER OF FORAGE ACRES IN SUBTYPES ON THE VARIATION OF FORAGE ESTIMATES BY THE RECONNAISSANCE METHOD



spread in forage estimates by the reconnaissance method largely may have resulted from the field procedure used in the study, in which the forage acreage of large subtypes was determined by accumulating forage acreages obtained from estimates on fractional subdivisions occurring within each section. One of the principal objections to the use of the reconnaissance method has been the assumption of difficulty in obtaining representative estimates of the forage on large subtypes. This objection may have originated from poor results obtained by averaging the forage factors from several subtype write-ups into a composite forage factor. While this may seem to represent a slight saving in computation, it nevertheless is an incorrect procedure. Since the vegetation seldom, if ever, is uniform on large subtypes the forage factor obtained from a separate write-up of one part of the subtype best represents the forage value of that part and may give a somewhat different per-acre value than write-ups of other parts of the subtype. Averaging these varied forage factors without giving weights to the area each represents results in an incorrect forage acreage for the subtype. Therefore, the forage acreages of the areas covered by individual write-ups always should be computed and these values summed to obtain the forage acreage of large subtypes. This procedure involves making separate forage write-ups of portions of large subtypes that occur in different sections on areas that have been surveyed and sectionized by the General Land Office. If the area is not sectionized or if the mapping is done on aerial photographs that do not show section lines, it involves breaking up the subtype into reasonable units for estimation purposes and showing the limits of each unit by "jibe lines."

This procedure works no hardship on the conduction of a range survey. It is often impossible for a field examiner to see an entire subtype in one trip across or through it, so as to include all its area in the same write-up. Similarly, in the case of two or more field examiners whose travel routes take them across the same subtype, at least as many write-ups will be made as the number of field examiners who encounter it. Therefore, it is the rule rather than the exception that several write-ups are obtained on large subtypes. Moreover, in computing the forage acreage of a considerable area covered by a range survey in country that has been surveyed and sectionized by the General Land Office, surface acreage of subtypes obtained by planimetering needs to be balanced section by section in order that total acreage shown by the range survey will be equivalent to that shown by the General Land Office survey. Thus, the subtype acreage is obtained by sections in the final compilation of surveyed range that has been sectionized by the General Land Office. These acreages of subtypes within different sections are totaled to obtain the area of the subtype. If the forage factors from the individual subtype write-ups have been averaged to obtain a single forage factor for the subtype, the forage acreage is procured by multiplying the surface acreage by this average figure, which, as heretofore stated may not yield a representative expression of the subtype's grazing value because the individual forage factors were not weighted by their acreage. Little if any more work is involved for the correct procedure of obtaining forage acreage of individual subtype write-ups by sections and adding these figures to get the total forage acreage of the subtype. Also, the increased accuracy of the forage estimate will more than compensate for the additional work

involved in computing the acreage of subtype units on range-survey type maps that are made of unsectionized land or that are derived from aerial photographs.

ESTIMATES OF FORAGE ACRES IN DIFFERENT SEASONS

The optimum time for estimating density is during the period when the important range plants are at or near their maximum growth. During that period the full spread of the plant can be seen and density estimates can be based directly on the percent of ground surface covered by foliage. It is uneconomical, however, to conduct range surveys for such a limited season. Density estimates, therefore, must be made previous to and subsequent to the time of maximum plant growth. They also have to be made of vegetation that has been grazed at intensities ranging from very light use to a degree where most of the foliage has been removed and can no longer be seen. Costello and Klipple (2), working with blue grama range, found that the forage estimate was much greater during the time of rapid growth of the blue grama than when the forage was dry. To overcome this tendency and maintain uniform density estimates throughout a range survey requires considerable mental reconstruction of the vegetation during periods when the vegetation is immature, when it is dried up, and when it is heavily grazed. During these periods, density and composition estimates are based largely upon the remnants of the vegetation remaining on the ground and their reliability depends to a large extent upon the familiarity of the field examiner with plant habit and his training and experience in mental reconstruction. It is necessary for the examiner to know the approximate size of grass clumps at full growth, basing his estimates upon a heavily

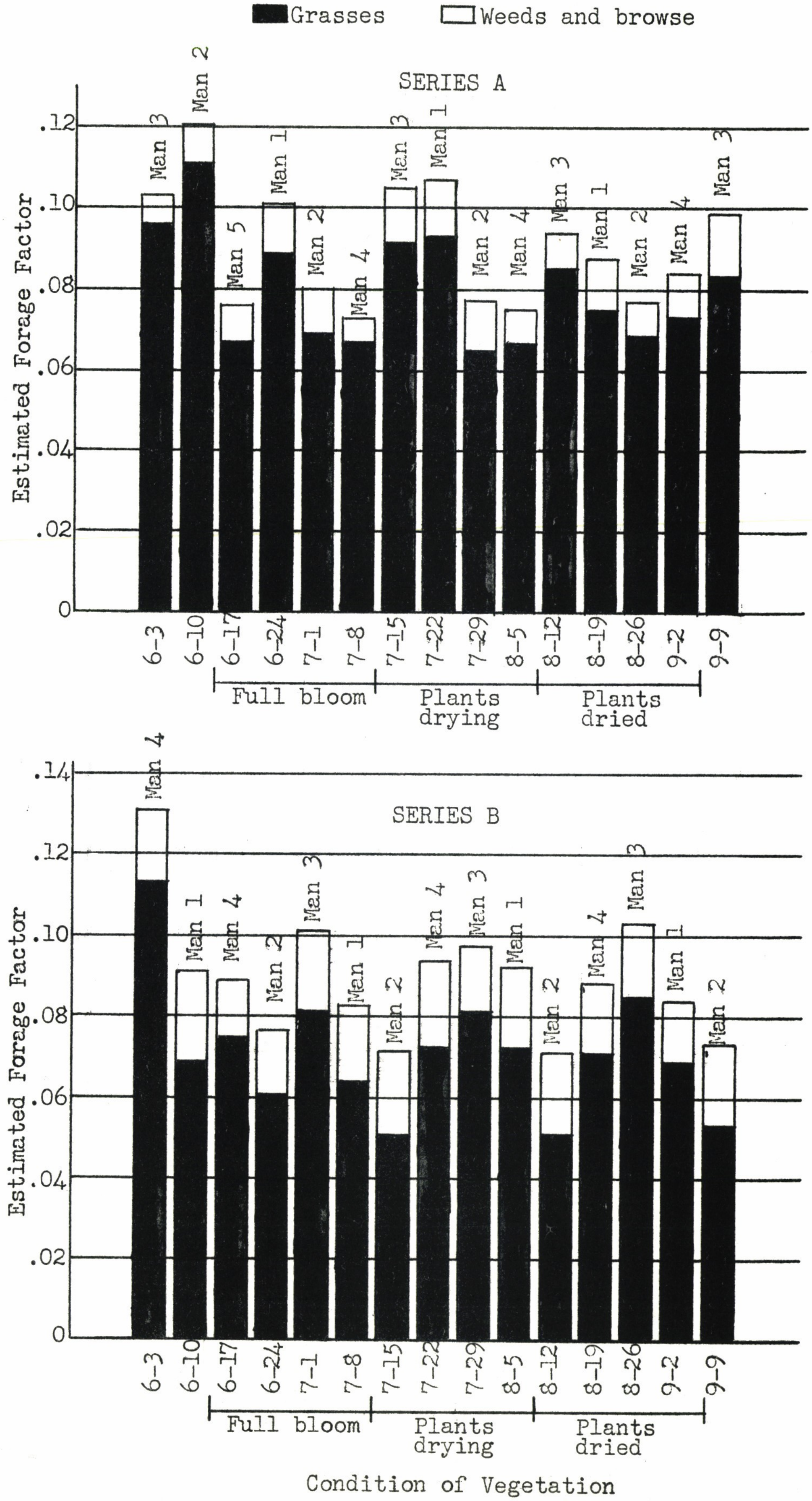
grazed stubble, or to know approximately the crown spread of the weeds for which he can only see the stems. This reconstruction is important to range-survey work because if not effectively accomplished forage estimates made during different months will not be uniform and forage acreage will not be comparable throughout the survey.

To determine whether or not the vegetation density effectively can be mentally reconstructed as the plants become increasingly dry and are subjected to increasingly heavy utilization, the forage estimates made weekly on two series of permanent plots (see page 38) were analyzed by variance. In making these estimates weekly throughout the season definite attempts to mentally reconstruct the vegetation were maintained. Estimates of forage made on the permanent plots for 12 consecutive weeks coincided roughly with three stages of the vegetation development--full growth, plants drying, and plants dried. The degree to which the plants were grazed on these plots was light during the period of full bloom, June 17 to July 8, inclusive; moderate during the period when the plants were drying, from July 8 to August 5, inclusive; and heavy during the period from August 5 to September 2, inclusive, when the plants were dried. These three periods also coincided quite closely with the time each block was surveyed on the 27 sections. Block 1 was surveyed during the period of best vegetation condition for estimating density and when forage utilization was light, block 2 when the plants were drying and utilization was moderate, and block 3 after the plants were dry and fully utilized. Forage estimates on the plots were also made on June 3 and June 10 during the training period and on September 9 after completion of the survey of the 27 sections. These were not included in the analysis.

The variance analysis (table 2) of the forage estimates made during the time when the vegetation was in full bloom and lightly grazed and on the same plots when the vegetation was drying and moderately grazed and when the vegetation was dried and heavily grazed shows that the estimates made during the different periods did not differ materially. There were no significant changes in estimates on the plots with season. This same consistency held for the estimates of total forage factor of all vegetation on the plots, for the forage factor of the weeds alone, and of the grasses alone for both the reconnaissance and the square-foot-density methods. Therefore, it can be concluded that the estimated forage value of the vegetation on the plots did not change as the vegetation condition changed. By mentally reconstructing the vegetation when only the dried, grazed portions of the plants remained, the men were able to estimate the forage essentially the same as if the vegetation were at full growth.

The bar chart of the forage estimates made by the reconnaissance method on series A and series B (figure 12) shows that while the men differed considerably among themselves each man was quite consistent in his estimates throughout the period of study. For example, man 2 varied in his estimates of forage factor of series B from .071 to .076. On series A he was high in his first estimate of the forage made on June 10 during the training period, but his other three estimates were quite uniform regardless of the condition of the vegetation; the average forage factor was estimated as .080 on July 1, .077 on July 29, and .077 on August 26. Man 3, who estimated above the crew mean whereas man 2 was always lower, estimated the forage factor on series A to be .103 on June 3, .105 on July 15, .094 on August 12, and .099 on September 9. This same consistency

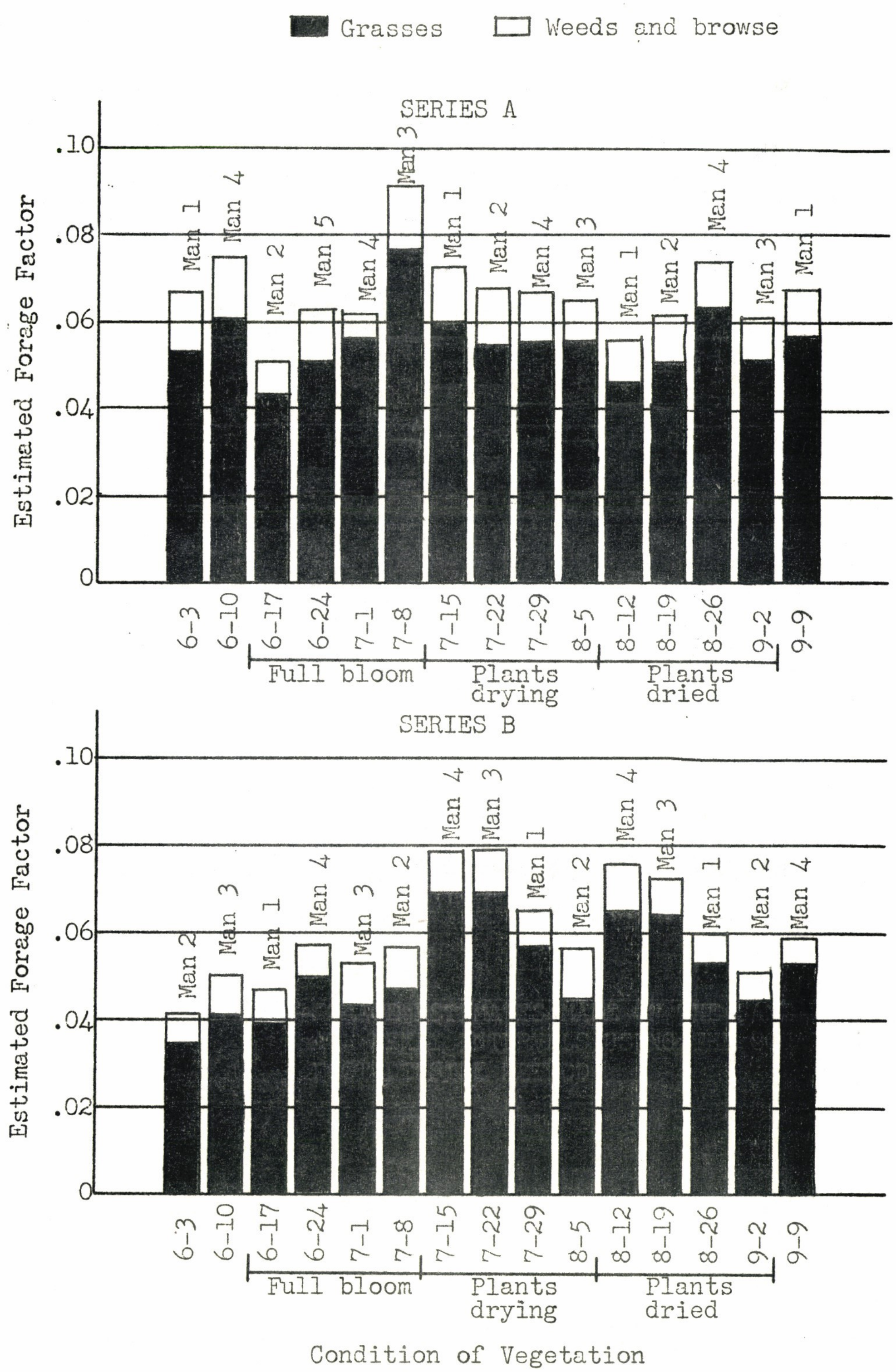
FIGURE 12.--FORAGE ESTIMATES MADE ON THE SAME PLOTS AT WEEKLY INTERVALS USING THE RECONNAISSANCE METHOD



was shown for all the men, the sampling accuracy (standard deviation) of a man on a series being ±.00870 (forage factor). As the average forage factor on the plots, determined by the reconnaissance method, was .0878, this indicates an accuracy of 9.9 percent. The same consistency of estimates by individual men was not obtained by the square-foot-density method (figure 13). On series A, for example, man 2 estimated the average forage factor as .051 on June 17, .068 on July 22, and .062 on August 19. Man 3 varied even more, varying on series A from .092 on July 8 to .061 on September 2, and on series B from .079 on July 22 to .050 on July 1. The standard deviation of a man in his estimates on a series of 9 plots by the square-foot-density method was ±.01256 forage factor, which is 19.1 percent of the average forage factor of .0657 for the two series of plots. The variance analysis showed, however, that for the square-foot-density method there were no consistent differences throughout this study between the men and that the differences in estimates of a single man were not related to the condition of the vegetation.

That the men were able to estimate forage as uniformly when basing their estimates upon dried vegetation as when basing them upon vegetation that was green and in full bloom was further demonstrated by the surveys of the Starkey range when using the type-sampling procedures. Both the reconnaissance and square-foot-density methods when using the type-sampling procedure showed (table 7) a greater variation in men between blocks than in men between sections within blocks. This indicates that the differences in forage estimates between men were not the same for all three blocks. From figures 8 and 9 it is apparent that forage estimates were more uniform in block 3 than in the other blocks. As block 3 was

FIGURE 13.--FORAGE ESTIMATES MADE ON THE SAME PLOTS AT WEEKLY INTERVALS USING THE SQUARE-FOOT-DENSITY METHOD



surveyed at a time when the vegetation was dried and quite heavily grazed, the greatest amount of mental reconstruction was required in estimating density for that block. However, by that time the men had the benefit of more than two months' experience upon which to base their density reconstructions, which apparently was sufficient to overcome the difficulty in effectively estimating vegetation under adverse conditions. Had the men not been able to continue estimating density throughout the season, this advantage would have been lost and the consistency of estimates doubtless would not have been maintained for all blocks as was the case.

FORAGE TYPE MAPS

Forage type maps bring data on forage and range conditions together in a form convenient for critical review and study when planning for the management of the range. A good map should show graphically the kind, amount, and location of forage and the location of features such as water, fences, and drainage units in such a manner that their relation to the numbers and movements of livestock can be better appreciated. It shows the extent of each kind of forage, something that is difficult to determine from field observations alone.

Proper location of the boundaries between different kinds of vegetation is prerequisite to a good estimate of the forage on the range because the acreage of each subtype enters into the forage-acre computations. With the reconnaissance method the forage factor of each vegetation association obtained from the vegetation write-up is multiplied by its area as determined from the type map. By the square-foot-density method data from the plots taken in each kind of vegetation are summarized

separately to the forage factor, which is multiplied by the area of the subtype. If the difference in forage value between adjacent subtypes is large, major errors in delineating the boundary between them will affect the forage estimate materially.

Type maps, to be easily understood, should show only essentials. The forage type map is used by the range administrator more than anything else that results from the range survey because it clearly shows the relation of his management problems to the forage resource. Therefore, because the range administrator often is unfamiliar with range-survey technique, the maps should be as simple as possible and yet should show all information on the range and range conditions which needs to be considered when managing the area.

MAPPING FORAGE TYPES AND SUBTYPES

Vegetation is classified for mapping on two bases: (1) Its general appearance, and (2) its important species. The major types are classified as to the general appearance of the range, which is the most obvious means of field identification, and are therefore shown with equal prominence on the map in standard colors. The subtypes show the distribution, kind, and amount of forage on the types. Subtype boundaries may coincide with type boundaries or they may be subdivisions of the type. If a grassland type contained only one kind and condition of forage it would contain but one subtype and the boundaries of both would coincide. Should it contain two kinds or conditions of vegetation, it would be separated into two subtypes each designated by its one or two most important species. Subtypes are the smallest subdivision of the vegetation recognized on range surveys

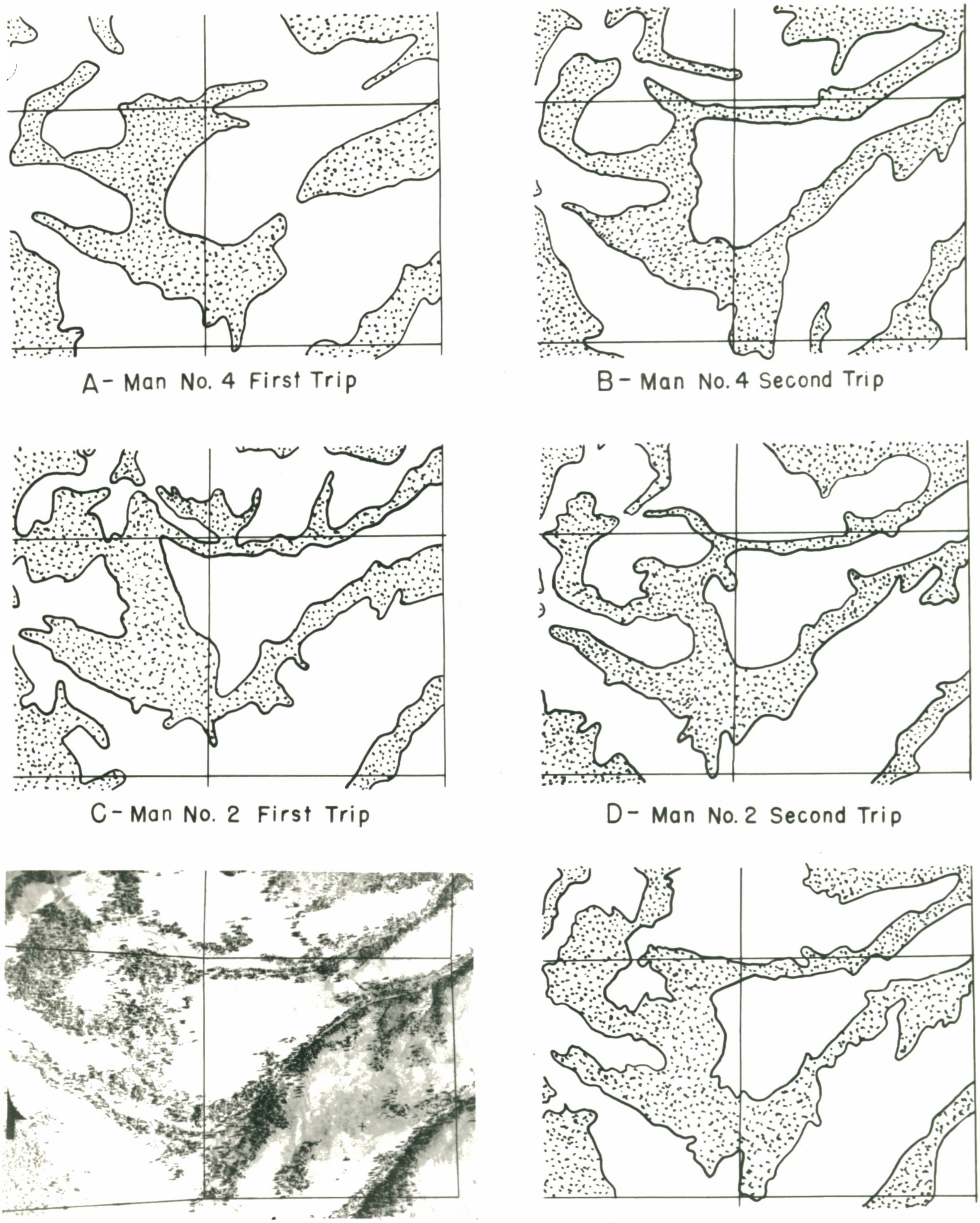
and are important because most management problems are associated with them.

Forage type maps cannot be of a high degree of accuracy because of the low cost at which surveys have to be made. The standard grid procedure (4), for example, requires the equivalent of one trip through each section for "extensive" surveys and two trips through each section for "intensive" surveys. With the "intensive" method used in this study, it was necessary for the field examiners to sketch type and subtype boundaries for a distance of one-quarter mile on either side of the traverse carried forward with pacing and compass.

Forage type maps were studied by comparing vegetation maps made by the five men when using the grid procedure with those made using aerial photographs. With the grid procedure variations shown in maps result both from error in drawing type and subtype boundaries and from the differences in their classification. When mapping directly on aerial photographs, the type and subtype boundaries were drawn before the examiners went into the field and differences shown between the men result only from differences in classification.

Type Boundary Delineation

That there is considerable error in drawing boundaries between types and subtypes by the grid procedure is clearly demonstrated by comparing maps of the same area drawn by different men and also as redrawn by the same man. Figure 14 demonstrates how boundaries drawn between coniferous and open range varied when drawn by different men and when redrawn by the same men on their second trip over the same area.



A- Man No. 4 First Trip

B- Man No. 4 Second Trip

C- Man No. 2 First Trip

D- Man No. 2 Second Trip

E-Aerial Photograph

F- From Aerial Photograph

Figure 14 — Forage type maps drawn by GRID method compared with that taken from aerial photographs

Open range   Timberland range

The outline of the main blocks of timbered range usually was shown on the map as similar in shape to that actually occurring on the ground, and in every case it was possible to recognize what the men were trying to sketch on the maps, but the size and detail of the boundaries of the areas were not accurately shown. The area demonstrated in figure 14 admittedly is easy to type because of the distinct boundaries between timber and openings, but it demonstrates the difficulty of drawing type and subtype boundaries by the grid procedure even when boundaries are distinct. Figure 15 shows maps of another area drawn by the same two men to demonstrate nature of the variation in drawing type boundaries for vegetation where boundaries are much less distinct. Here the outlines of the types as drawn by the men varied much more because of the increased difficulty in actually seeing the boundaries on the ground. The vegetation changes that indicated type boundaries were not always abrupt, and in other instances the tree growth made long-range visibility poor.

Maps drawn by men who had little previous mapping experience were usually much more generalized in character than those made by men who had previous mapping experience. Another characteristic of maps made by inexperienced men was that the width of stringers of forage types along creek bottoms and on sidehills was overestimated or else the types were left out entirely. As the season advanced their maps became more nearly on a par with those made by the more experienced men. This is demonstrated in figure 14, which shows maps drawn by man 4, who had no previous mapping experience, and man 2, who had a year's experience on range surveys. On the first trip through the area the map drawn by man 4 was much poorer and more generalized than that made by man 2.

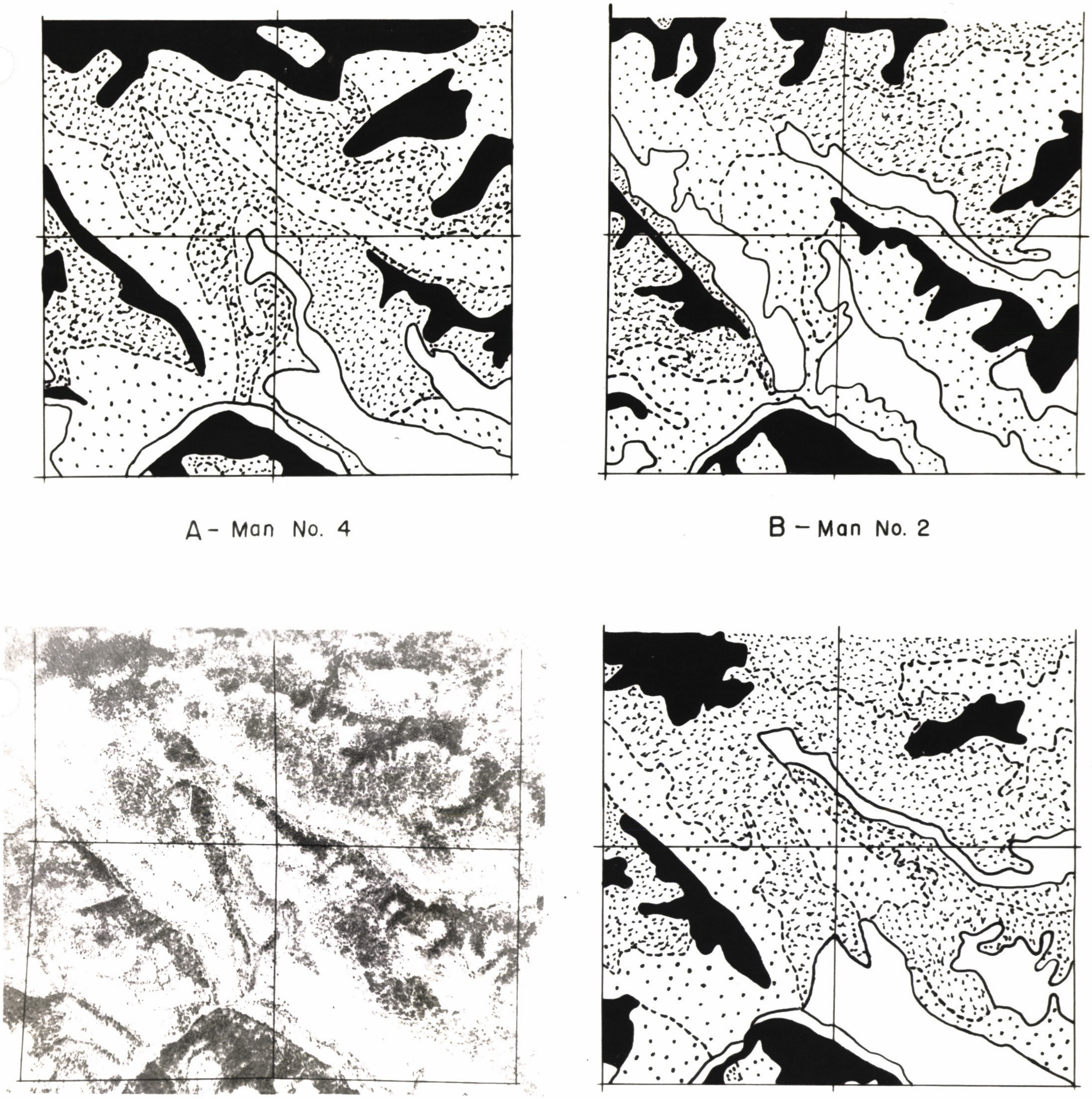


Figure 15 - Forage type maps drawn by GRID method compared with that taken from aerial photograph as classified by the majority of examiners

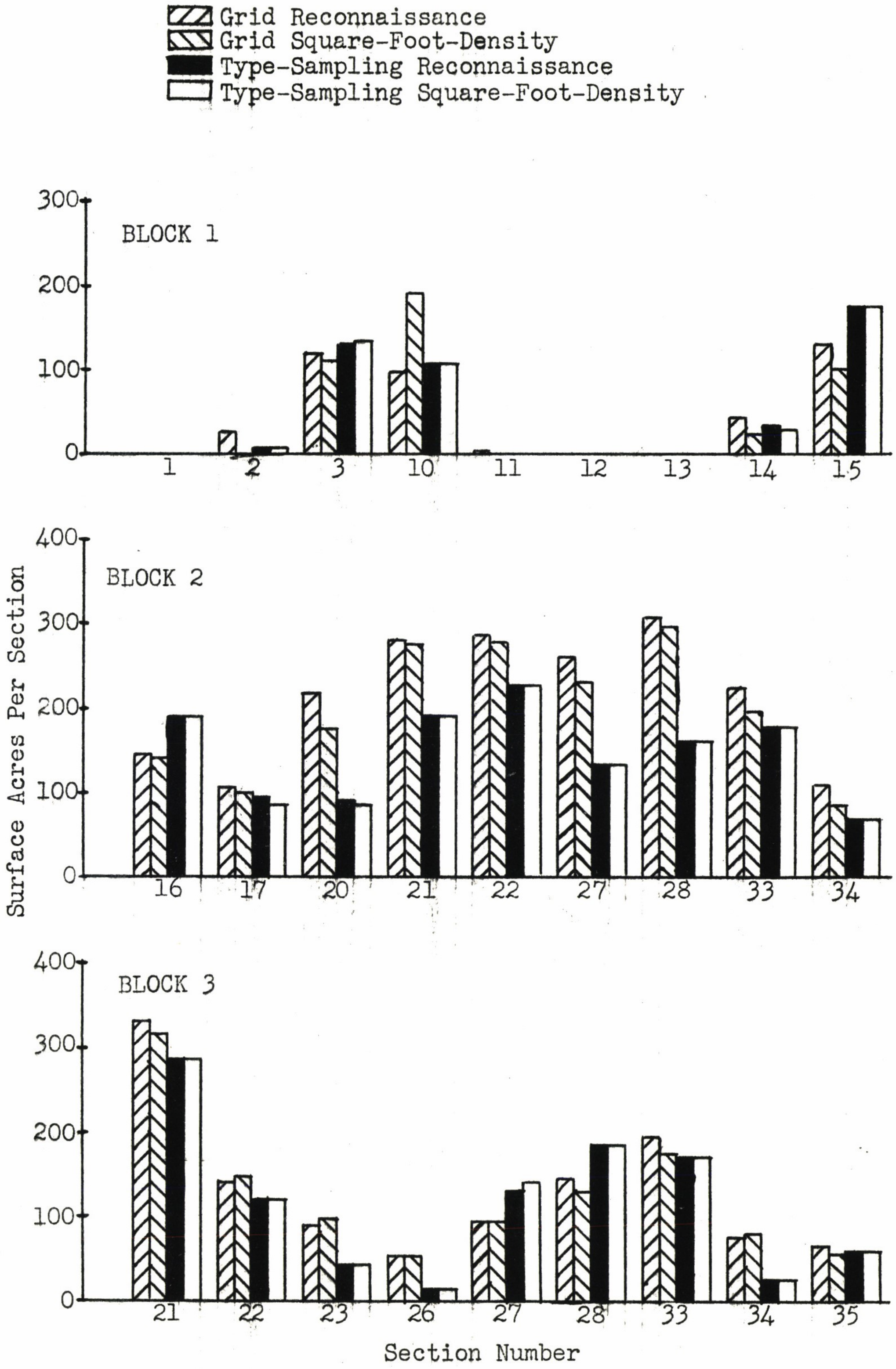
Grassland or meadow
Timberland range with bunchgrass understory
" " " pinegrass weed "
Waste range
— Type boundaries
---- Subtype boundaries

On the second trip the map drawn by man 4 was more nearly on a par with that drawn by man 2. The area shown in figure 15 was surveyed near the end of the field season and at that time the influence of previous mapping experience had largely been eliminated. When it is realized that the improvement shown by man 4 in figure 14 resulted from one week's mapping experience, the need for practice in mapping prior to the beginning of the field work can be appreciated.

The area sketched on the map as waste range (type 7) by the grid procedure consistently was greater than that obtained using the aerial photographs. The area classified as densely timbered waste range by the grid procedure averaged 124 acres per section for the square-foot-density method and 131 acres per section for the reconnaissance method as against 104 acres per section classified as waste by both methods using aerial photographs. This overestimate of waste range by use of the grid procedure is important because no grazing value is assigned to this type. A consistent overestimation of its area, therefore, markedly decreases the estimated amount of forage on the range.

From figure 16 it will be noted that the overestimate of waste range was not as great in blocks 1 and 3 as in block 2. In blocks 1 and 3 the area classified as type 7 usually occurred as dense stands of lodgepole pine and of Douglas-fir, Engelmann spruce, and grand fir on north slopes and stream bottoms. Such areas commonly were rather narrow with very distinct boundaries as the result of abrupt changes in topography. In block 2, however, the waste range occurred as timber thickets on flats and ridgetops in large areas as well as on north slopes and stream bottoms, and was characterized by having rather indistinct boundaries and containing

FIGURE 16.--AVERAGE AREA OF WASTE RANGE (TYPE 7)
AS SHOWN BY EACH SURVEY METHOD



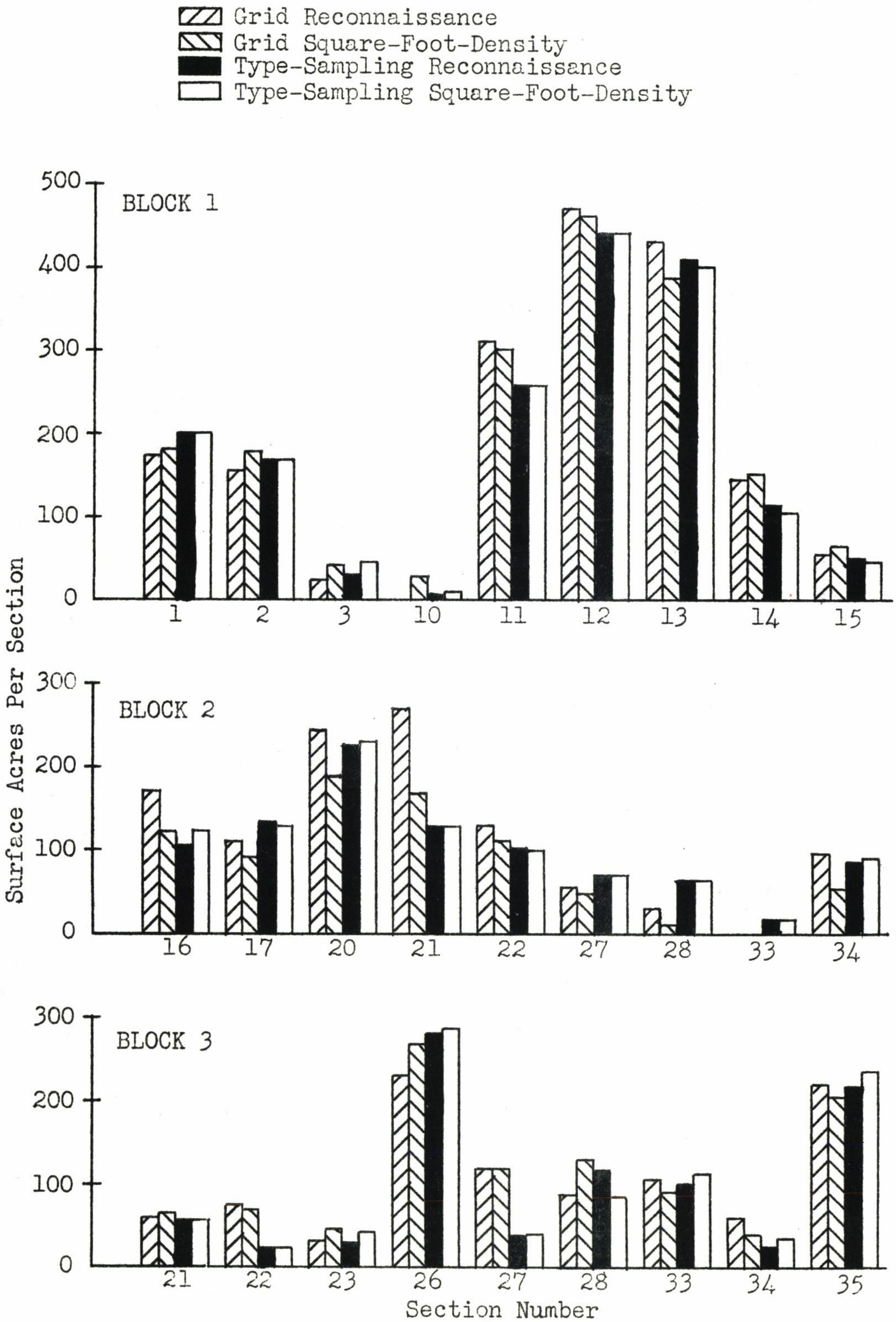
scattered patches of usable forage. By the grid procedure the small, distinct waste range areas in blocks 1 and 3 could be quite easily recognized and their boundaries determined. Because of the gentle topography and poor visibility on block 2 the examiners had difficulty determining the extent and boundaries of the unusable areas when mapping from compass lines at half-mile intervals. Under these conditions the boundaries of the waste range usually were extended too far and areas of usable forage scattered through the timber often were overlooked. By the use of aerial photographs, the boundaries could be more easily determined and the scattered areas of usable forage identified.

The area of untimbered range (figure 17) was overestimated by the grid procedure but not to the same extent as was the area of the 7 type. By the reconnaissance method the average area of open range per section, including grassland, meadow, and sagebrush, was shown to be 141 acres per section by the grid procedure, compared with 129 acres per section by the type-sampling. By the square-foot-density method the difference was even smaller, averaging 134 acres per section for the grid procedure compared to 132 acres per section for the type-sampling procedure.

Type Classification

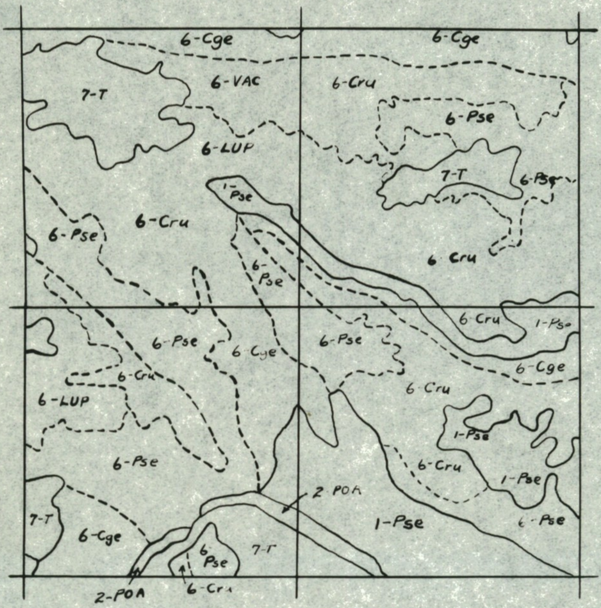
The second source of variation in forage types, differences in classification, is not serious from the standpoint of the forage-acre computations or from using them to plan improved range management. However, the types usually are shown prominently in colors on the final map and are the most obvious, the most used, and the most readily understood

FIGURE 17.--AVERAGE AREA OF ALL OPEN RANGE (TYPES 1, 2, and 4) AS SHOWN BY EACH SURVEY METHOD

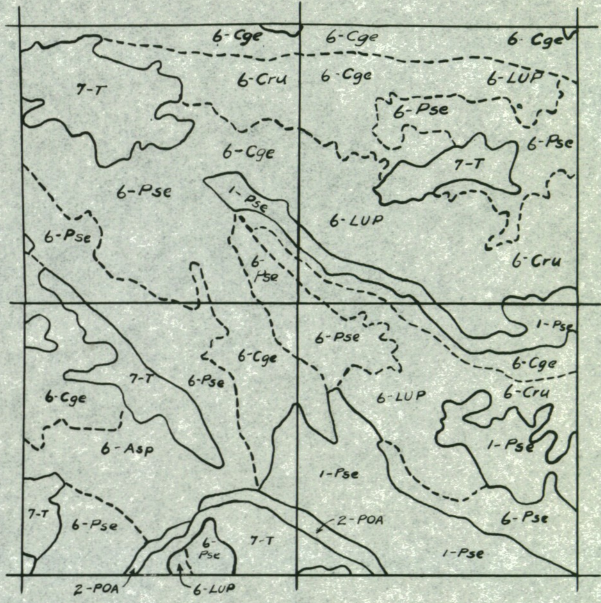


of all the data shown on the completed range survey. Any discrepancy in type designation, while usually unimportant to management of the area, often tends to discredit the map and even the entire results of the survey when discovered by a person not thoroughly schooled in the range-survey method.

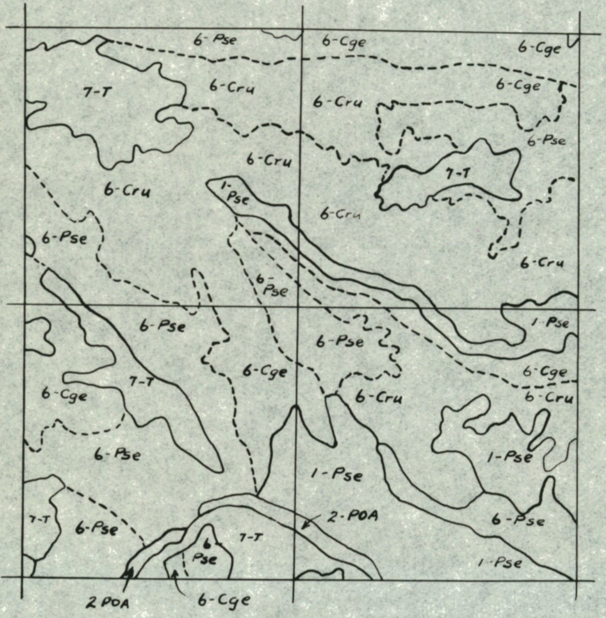
While it would appear that broad type classifications such as grassland, meadow, sagebrush, and conifer are quite distinct and easily identified, analysis of the maps made by the type-sampling procedure in this study, where the forage within the same type boundaries was classified by different men and also reclassified by the same men (figures 18 and 19), showed that opinions can differ as to the general appearance of the range. Such differences occur principally on borderline types. Grassland ranges containing no tree growth were never classified as timber range, but in several instances there was some confusion between grassland and dry meadow types where seasonal springs and seeps occurred. Likewise, timbered ranges with a uniform tree overstory were usually classified as conifer ranges. However, well-grassed ranges containing occasional trees often were classified either as timber or grassland by different men, and the same man often classified them differently on his second trip through the area. No hard or fast rule by which to classify borderline types can be made which will fit all conditions. Therefore, the fact that these differences in classification can be expected in range surveys should be understood clearly by all who use the maps in managing the range. It should be recognized that, except for waste or nonusable range types, errors in type classification do not affect the estimate of the amount of forage. It is of considerable



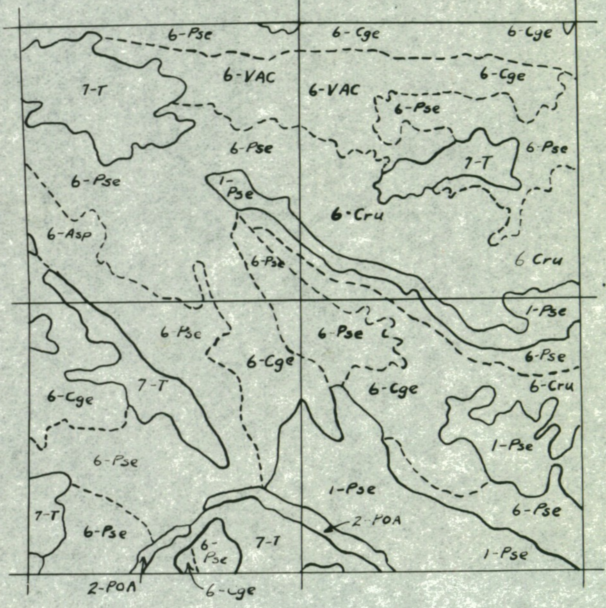
MAN NO. 1 ⇄



MAN NO. 2 ⇅

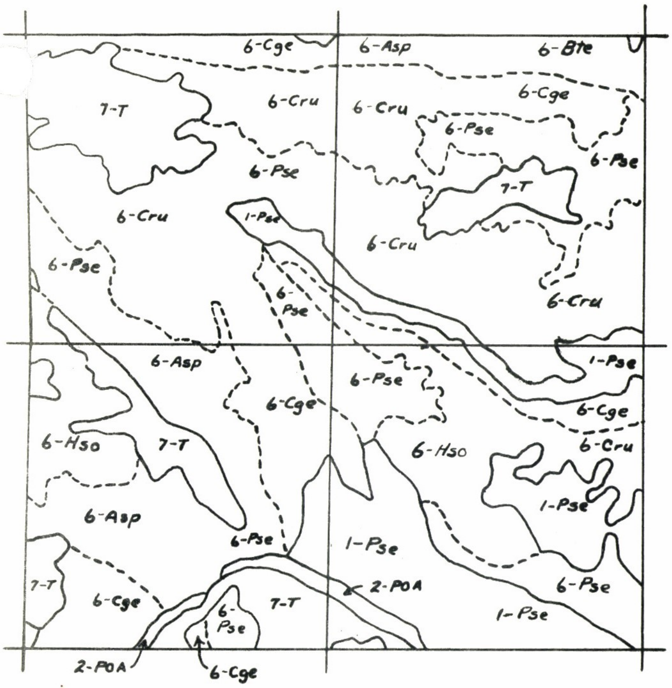


MAN NO. 4 ⇅

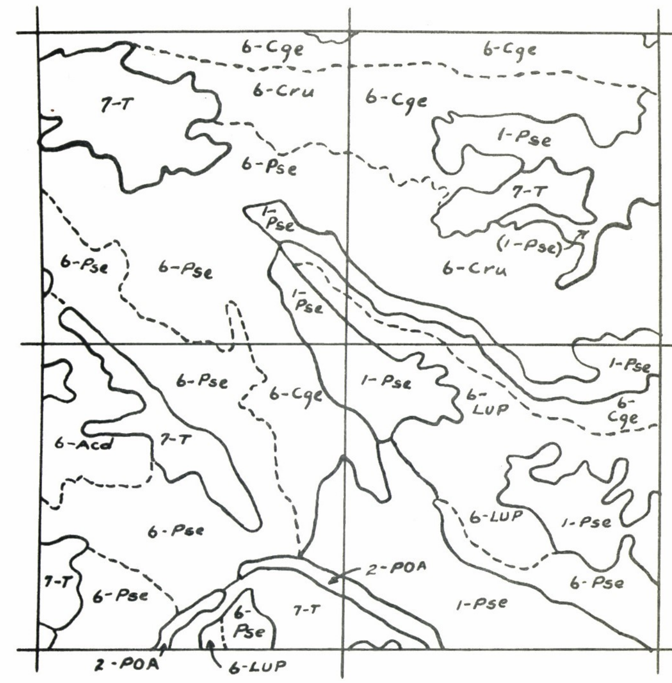


MAN NO. 5 ⇅

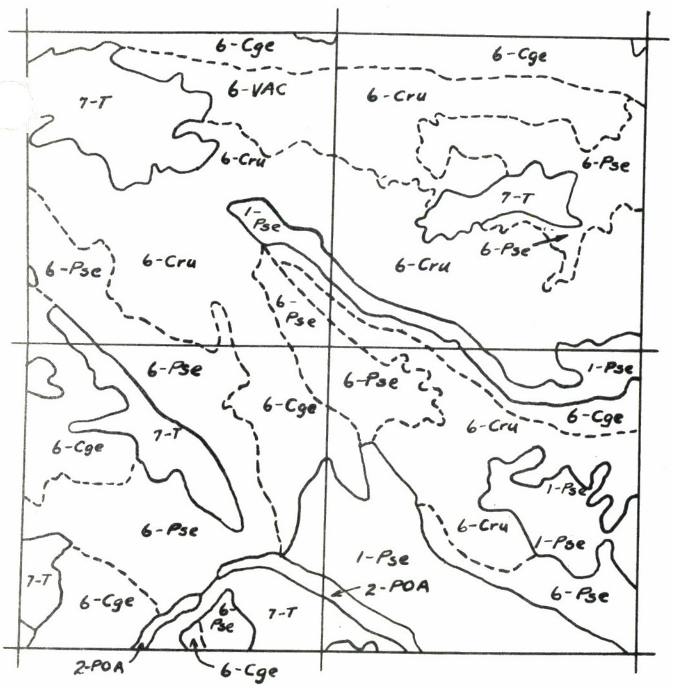
FORAGE TYPE MAPS OF 4 SECTIONS SHOWING HOW FOUR MEN CLASSIFIED THE VEGETATION WITHIN THE SAME BOUNDARIES



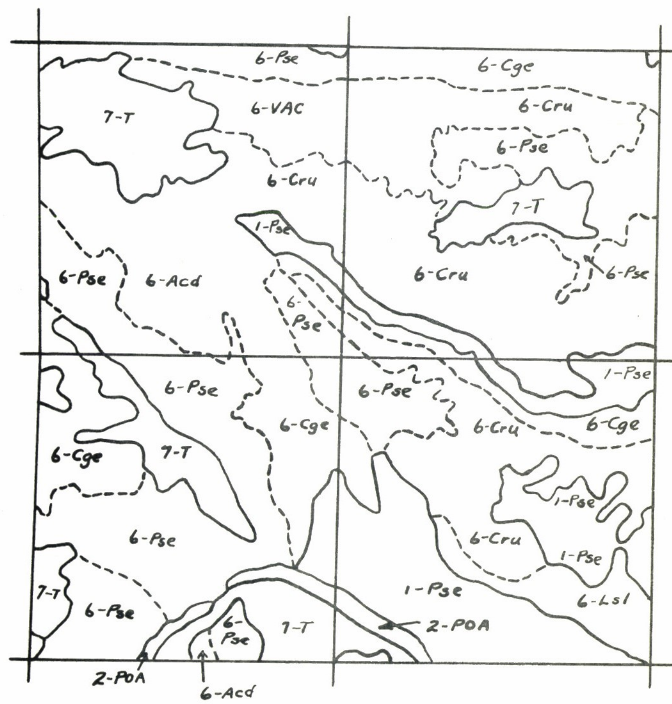
MAN NO. 1 ⇅



MAN NO. 2 ⇄



MAN NO. 4 ⇄



MAN NO. 5 ⇄

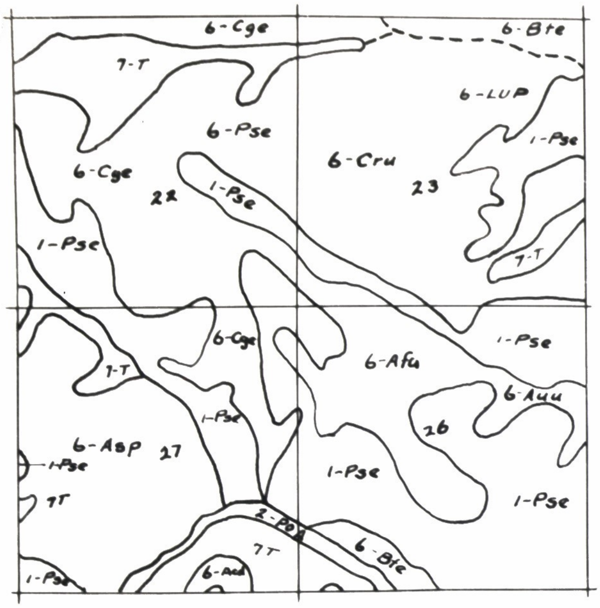
FIGURE 19.--FORAGE TYPE MAPS SHOWING HOW THE MEN RECLASSIFIED THE VEGETATION WITHIN THE SAME BOUNDARIES AS USED WHEN MAKING THE CLASSIFICATION SHOWN IN FIGURE 18 BUT TRAVERSING THE AREA IN A DIFFERENT DIRECTION

importance for the range administrator to know that what appear to him as discrepancies in the designation of types on the forage map from the appearance of the vegetation are not significant errors, but rather are differences in interpretation.

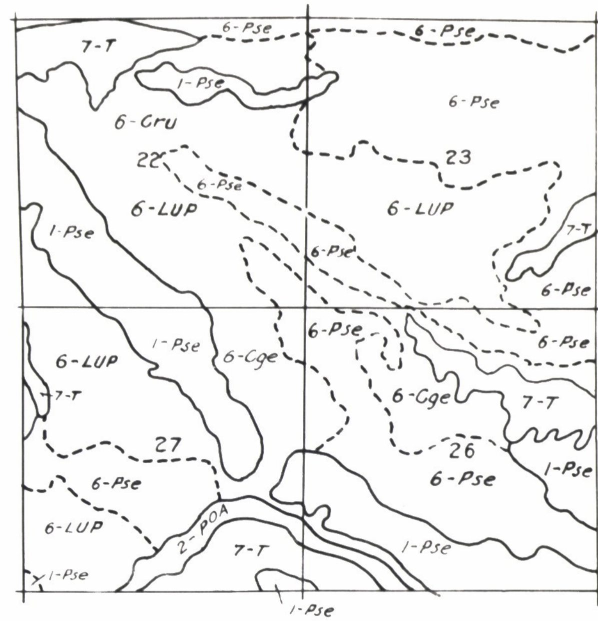
<u>Subtype Classification and Boundary Delineation</u>

The variation in mapping subtypes was studied by comparing the maps drawn by the five men (figures 20 and 21). Sources of variation in mapping subtypes are similar to those shown for types; that is, error in (1) drawing the subtype boundaries, and (2) classifying the subtypes by designating the main species that occur. The amount of variation in mapping and designating a subtype largely depends on the nature of the change that separates it from the surrounding vegetation. When changes in vegetation occur within types, their boundaries are more difficult to draw than when they coincide with type boundaries. Subtype boundaries were shown by some men which were not shown by others and sometimes were not shown by the same man when he drew the map of the same area the second time.

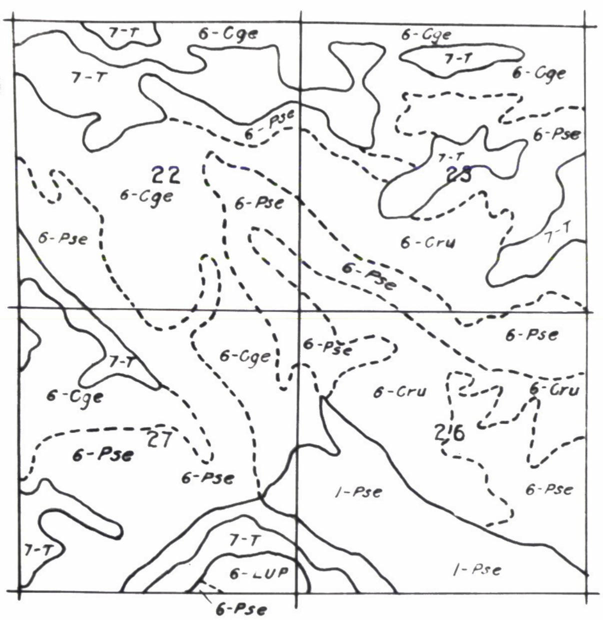
On the maps drawn in this study, subtypes whose boundaries consisted of rather abrupt changes in vegetation and which contained one species outstandingly more important than the remainder of the species in mixture usually were recognized by all of the examiners, were given the same subtype designation and were subject to errors in boundary delineation similar to those for types. Subtypes which had rather definite boundaries but which had several species in mixture of nearly equal importance usually were given the same general boundaries but were not always given the same



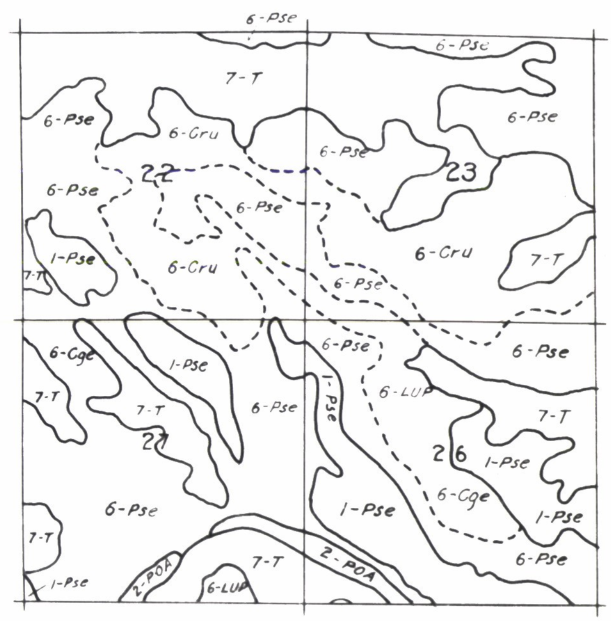
Man No.1 ⇅



Man No. 2 ⇄

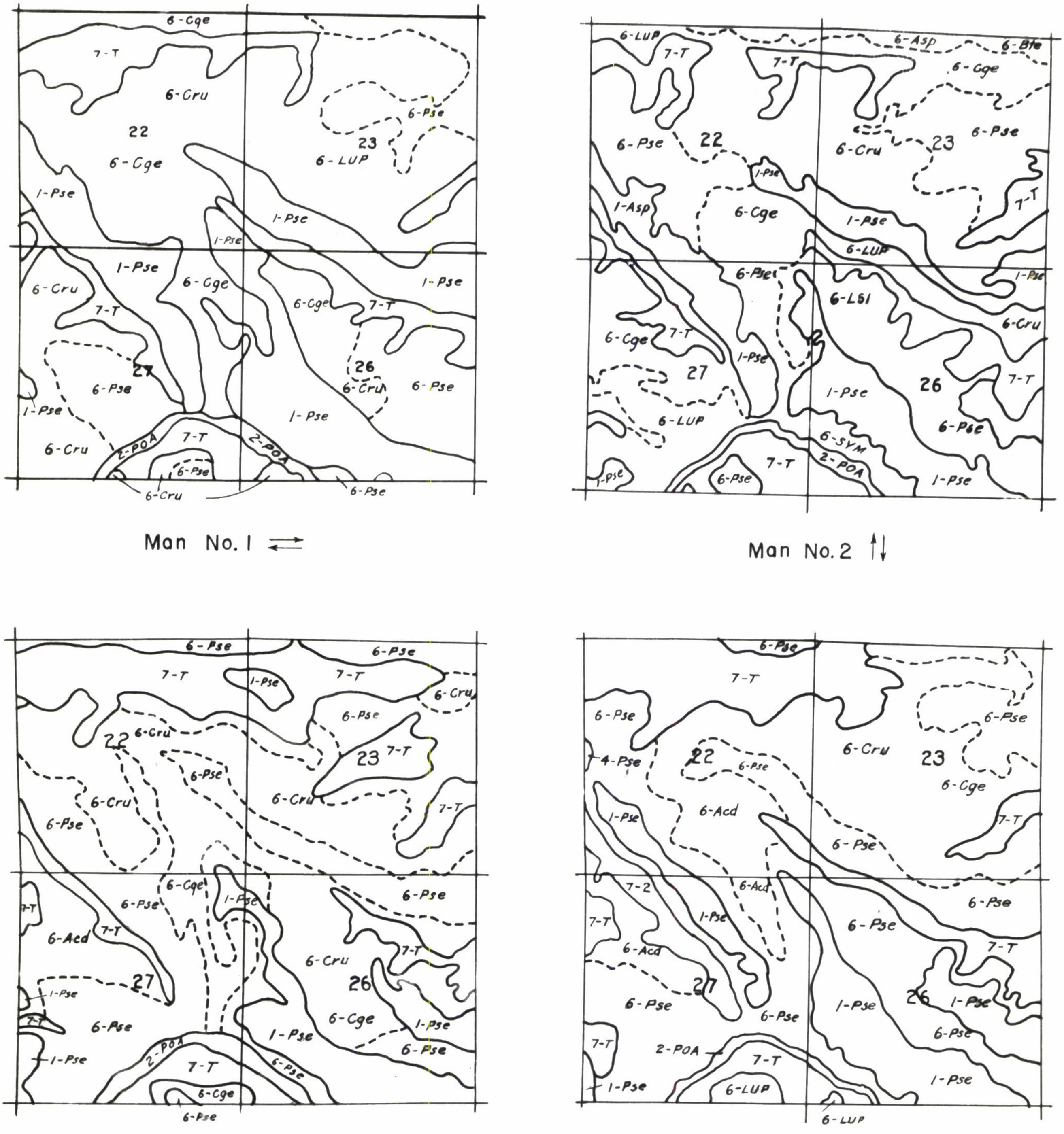


Man No. 4 ⇅



Man No. 5 ⇄

Figure 20 - Forage type maps of four sections as drawn by four men on their first survey of the area. (Types bounded with solid lines, subtypes with dashed lines. Figures show type number and letters subtype designations. ⇄ Shows direction of strips through sections)



Man No. 1 ⇄

Man No. 2 ⇅

Man No. 4 ⇄

Man No. 5 ⇅

Figure 21 - Forage type maps of the same four sections drawn by same four men as shown in Figure 20 on their second survey of the area (Types bounded with solid lines, subtypes with dashed lines. Figures show type number and letters subtypes designations. ⇄ Shows direction of strips through sections)

subtype designations. Those for which boundaries were indistinct by virtue of the vegetation changing gradually from one combination of species to another and on which one species was outstandingly more important than the other species in mixture, were usually classified the same, though the boundary locations varied widely. Subtypes with indistinct boundaries and ~~subtypes~~ which were combinations of many subtypes too small to consider separately varied widely in respect to boundary location and species designation.

With these kinds of variation occurring among subtypes, it is evident that range-survey maps may often contain subtypes which, while recognized by the field examiner, will not be recognized by the administrator who uses the completed map. In many instances field examiners using the reconnaissance method recognize subtypes that do not represent important vegetation changes because of the necessity to simplify the forage estimates. Care should be taken to show on the final map only those subtypes that can be recognized in the field and which are the largest units that will retain the identity of the forage on the range that is needed for range-management purposes. Any nonessential subtypes will serve only to confuse the range administrator, thereby causing the maps to lose much of their usefulness.

THE USE OF AERIAL PHOTOGRAPHS IN MAPPING RANGE VEGETATION

Aerial photographs are an aid in securing more accurate maps of the forage types and subtypes. Their use has several advantages over mapping by the grid procedure. They eliminate the need for following a definite line of travel through the range in order to carry forward a mapping control

by compass and pacing. The examiner can use ridges, streams, trees, and other features that appear plainly in the photographs to locate type boundaries. Differences in color tones on the photograph often indicate changes in vegetation. Moreover, the examiner has more liberty to follow boundaries between types and can thereby locate them quite accurately on the contact print for later transfer to the planimetric base map.

That aerial photographs have definite advantages over the grid procedure is demonstrated by the sample shown in figure 14, which has been greatly reduced in scale from the photographs used in the field work. The boundaries of the timber stand can be seen easily, and in open timber stands individual trees often can be identified. With this as a guide, the boundaries between types can be drawn easily. Aerial photographs are of even greater help in drawing type maps of areas similar to that demonstrated in figure 15. Without aerial photographs, the boundaries between types are rather difficult to determine, and it is even more difficult to map the correct areas of the subtypes that are known to occur. In this particular instance the forage consisted of open grassland type and of coniferous timber type which contained two subtypes, bunchgrass and pinegrass-weed mixture. It was very difficult to determine the extent of the intermixed bunchgrass and pinegrass subtypes without the aid of the photographs. It is possible, however, to determine from differences in the shading on the aerial photographs the extent of the grassland type, and also to separate conifer-bunchgrass subtypes from conifer-pinegrass.

A comparison of the photograph and the planimetric map taken from it in figure 15 will undoubtedly lead the reader to the conclusion that

the boundary locations for types and subtypes shown on the planimetric base map could be changed in many instances. It is true that in a mixture of vegetation similar to that shown, exact boundary locations are open to interpretation even with the use of aerial photographs and, therefore, the method of type mapping by means of aerial photographs is not entirely accurate. However, on areas where changes in vegetation are sharper, boundary locations are not subjected to as much personal interpretation. The principal advantages of mapping with aerial photographs are: (1) That the field examiner can determine his location, with reference to the print, accurately and easily; (2) that he can draw the boundaries of the types and subtypes as he sees them on the ground quite accurately and quickly by the aid of ground features readily discerned on the photograph; and (3) that, by virtue of his freedom of travel, through being able to locate himself on the photograph at all times, he can include in the forage write-up of each subtype a more representative sample of the vegetation within its boundaries. These distinct advantages of using aerial photographs should improve the reliability of range surveys.

INVENTORY OF OTHER FACTORS AFFECTING MANAGEMENT OF THE RANGE

It is essential that a range survey provide a knowledge of the problems involved in obtaining proper forage management and an inventory of the facilities that can be used effectively in solving these problems. From the range-management standpoint, this information is equally as important as the forage inventory. For each allotment the range survey should determine whether the kind of livestock being grazed is the most

suitable and is the one that will most efficiently utilize the forage. It should determine whether the season of use is the most desirable from the standpoint of maintaining the maximum forage production; whether adjustments are needed in the opening or closing dates of the allotment or in the seasonal distribution of livestock within the range. Likewise, it should determine whether the proper number of livestock are being grazed and if the proper distribution of the livestock has been obtained. Current practices and needed adjustments in the livestock management on each allotment should be studied as an aid to solving problems in the management of the forage.

The inventory of factors affecting management should include adequate description and location of water facilities, salt grounds, sheep camps, rodent infestations, poisonous plant areas, eroded or denuded areas, wildlife, livestock barriers, and all cultural features on the area including fences, corrals, roads, trails, troughs, telephone lines, and buildings. In addition, notes should be obtained on concentration areas, past and present use of the forage, herding methods, habits of the livestock on the range, range improvements needed and recommended for construction and reasons therefor, condition of the vegetation, use of the range by game animals and conflict of grazing of domestic animals with other legitimate uses of the area such as timber production, recreational use, and watershed protection.

Many of these data are collected by the field examiner when making the forage write-up of each subtype. He shows in place on the map as much of the data as possible. The field examiner, however, surveys only a small part of each range allotment, and is not always able to determine

the relationship between management problems on the area he surveys and the remainder of the allotment. Therefore, one of the duties of the chief of party should be to make a complete inspection of each allotment, obtaining information supplemental to the notes taken by the field examiner. Through study of the notes taken by the field examiners and through observation of conditions on the range, he should become thoroughly familiar with the problems and with the measures needed for their solution on each allotment before completing the field work.

On most range surveys made in the past the chief of party has relied upon the field examiners to collect much of the data on range conditions, livestock distribution, and range improvements. To determine the effectiveness of field examiners in collecting these kinds of data when making the forage inventory of the range, each of the five men surveying the 27 sections made a complete write-up of all pertinent information of this type after his first trip through each block. At all times they located on their maps as accurately as possible features such as available water, fences, and salt grounds. The conclusion reached after studying the descriptions of management problems on each block was that the quality of these data varies more with the abilities of the field examiner than with the range-survey method used.

As an example of how well the field examiners find and show on the map range improvements already existing and possibilities for further developments which would aid in improving range conditions, the number of springs and salt grounds recorded by each man on his first trip through the range was tabulated (table 10). From a study of these data it appears doubtful if the field examiners will find and accurately locate

Table 10.--Number of salt grounds and springs found by each man on his first range survey of each block and number known to the association rider, compared with the total number of salt grounds and springs

	Total on area	Water1/ and salt grounds found											
		Rider		Man No. 1		Man No. 2		Man No. 3		Man No. 4		Man No. 5	
		Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Block 1													
Salt grounds	8	8	100	2	25	2	25	1	12	2	25	0	0
Water--Developed springs	1	1	100	1	100	1	100	1	100	1	100	1	100
Usable springs	7	5	71	2	29	3	47	2	29	3	47	4	57
Of doubtful use	2	1	50	0	0	0	0	0	0	1	50	0	0
Total (springs only)	9	6	67	2	22	3	33	2	22	4	44	4	44
Block 2													
Salt grounds	6	6	100	3	50	3	50	1	17	3	50	4	67
Water--Developed springs	6	6	100	4	67	3	50	3	50	3	50	3	50
Usable springs	9	8	89	6	67	5	56	4	44	4	44	5	56
Of doubtful use	2	0	0	0	0	0	0	0	0	0	0	0	0
Total (springs only)	11	8	73	6	55	5	45	4	36	4	36	5	45
Block 3													
Salt grounds	8	8	100	3	38	2	25	4	50	2	25	3	38
Water--Developed springs	0	--	--	--	--	--	--	--	--	--	--	--	--
Usable springs	8	7	88	3	38	1	12	1	12	2	25	2	25
Of doubtful use	6	1	17	1	17	0	0	1	17	0	0	1	17
Total (springs only)	14	8	57	4	29	1	7	2	14	2	14	3	21
Total area													
Salt grounds	22	22	100	8	36	7	32	6	27	7	32	7	32
Water--Developed springs	7	7	100	5	71	4	57	4	57	4	57	4	57
Usable springs	24	20	83	11	42	9	37	7	29	9	37	11	42
Of doubtful use	10	2	20	1	10	0	0	1	10	1	10	1	10
Total (springs only)	34	22	65	12	35	9	26	8	24	10	29	12	35

1/ Live streams excluded.

all of the important management features even when using standard range surveys at their maximum intensity. None of the field examiners found more than 11 out of 24 springs that were considered important to the management of the area. A greater percentage of the springs was found in blocks 1 and 2 than in block 3. On these two blocks cattle had been grazed for many years and trails, radiating out from the springs, could be used to guide field examiners to the springs. Block 3 had been grazed by cattle only a short time and the springs were not as well marked.

No greater percentage of salt grounds was found. Of the 22 marked salt grounds on the 27 sections, one man found 8, three men found 7, and one man found 6. Of 8 salt logs in block 1, three men found 2, one man 1, and one man none.

It is true that on a range survey springs or other management features not located by the field examiners may be known to the stockmen using the range and that much information which the field examiner misses can be supplied later. However, when locating these on the map from memory considerable error is incurred, and the relationship between forage and water, for example, might be misrepresented. It is suggested, therefore, that the chief of party take the aerial photographs or the sketched type map into the field and check the location of all springs, salt grounds, or other features that affect utilization of the forage. This inspection should be made in company with the district ranger or the stockman or his representative. By this means he can accurately locate all these features and can discuss the management problems on the ground with the man most familiar with them. This procedure was tried on the experimental area, and for comparison the number of springs and salt grounds shown the chief

of party by the range rider is given in table 10. By using this procedure all of the salt grounds, all of the water developments, and 20 of the 24 important springs were accurately located on the map. The increased value of the survey by the addition of this information should be sufficient to justify the time required by the chief of party in collecting it, and in addition it assures a more intimate knowledge of the management problems on the part of the chief of party, who is charged with the development of the management plan. The suggested procedure should not relieve the field examiners of the responsibility for locating these management features, as data collected by them are supplemental to those collected by the chief of party. On the experimental area four good springs were found by the field examiners in dense timber stands which were not known to the rider. These were strategically located, and their development would importantly affect the use of the adjacent forage.

The successful application of a range survey as a means of developing practical and effective plans for proper range and livestock management largely depends on the ability and experience of the chief of party in charge of the survey. His duties are twofold: That of directing the work of the field examiners in obtaining uniform forage estimates and data on range conditions; and that of inspecting each range allotment personally to study the management practices in force and to determine measures for their improvement. Failure in either of these impairs the usefulness of the range survey. Therefore, a good range survey requires a chief of party who is experienced and proficient in the forage inventory phases of range surveys, who can recognize and interpret good and bad range conditions and management practices, and who has had experience in practical range administration.

RELATIVE COSTS OF THE SURVEY METHODS

Records were kept during the study to determine cost of the range surveys. Since it is realized that per-acre costs vary for different terrain, intensity of survey, efficiency of crew, and many other factors, it is understood that the principal value of the data is to compare the relative costs of the methods. Records of costs were maintained on 16,987 acres surveyed separately by five field examiners when using each of the four survey methods, or a total of 84,935 acres surveyed by each method. An area of this size surveyed by the same crew should give a good indication of the relative costs of the different methods.

COST OF THE FIELD SURVEY

Cost studies show that if the area to be surveyed previously has been flown so that the aerial photograph negatives and the planimetric base map are available without cost, range surveys can be made for approximately the same cost per acre using the reconnaissance method whether by the grid procedure or mapping directly on the aerial photographs (table 11). The cost per acre for the survey by the reconnaissance method was 9.00 mills[13] when mapping on aerial photographs and 9.09 mills when using the grid procedure. Costs for the type-sampling procedure include contact prints, sectionizing prints, all field and camp mapping and computations, and the transfer to scale of all forage and physical feature data from the contact prints to the planimetric base map. The cost

13/ Costs given are the actual expense of field work exclusive of the cost of training and moving camp. Costs are for chief of party at $2,600 per annum, 5 field assistants at an average of $120.33 per month plus board, a cook at $95.00 per month plus board, and transportation.

Table 11.--Relative cost[1] of range surveys made by the four methods

Item	Grid procedure				Type-sampling procedure			
	Reconnaissance		Square-foot-density		Reconnaissance		Square-foot-density	
	Cost per acre (Dollars)	Per-cent	Cost per acre (Dollars)	Per-cent	Cost per acre (Dollars)	Per-cent	Cost per acre (Dollars)	Per-cent
Field	.006721	93.2	.006471	80.2	.005846	94.0	.006751	79.1
Field mapping	.006025	83.5	.006471	80.2	.005024	80.8	.006751	79.1
Field compilation	.000696	9.7	--	--	.000822	13.2	--	--
Camp	.000493	6.8	.001596	19.8	.000370	6.0	.001785	20.9
Camp mapping	.000493	6.8	.000403	5.0	.000370	6.0	.000346	4.1
Camp compilation	--	--	.001193	14.8	--	--	.001439	16.8
Total field and camp	.007214	100.0	.008067	100.0	.006216	100.0	.008536	100.0
Travel time to and from work[2]	.001562		.001505		.001359		.001570	
Total cost of field survey	.008776		.009572		.007575		.010106	
Miscellaneous								
Contact prints					.000344		.000344	
Sectionizing prints					.000297		.000297	
Drafting type map	.000312		.000312		.000781		.000781	
Cost of completed map[3]	.009088		.009884		.008997		.011528	

1/ Based upon actual cost of survey exclusive of training and moving camp.
2/ Cost of travel time distributed proportionally to field time.
3/ Cost of completed map ready for planimetering.

for the grid procedure includes field and camp mapping and computations and the transfer of all field work to the final tracing. From this point on (computation of surface acres and forage acres of the types, etc.) summarization of the range-survey data is the same for both procedures and, therefore, costs should be identical.

The time spent in field and camp work by the type-sampling reconnaissance method was less than for the grid reconnaissance method, averaging 3.54 hours per section and 4.11 hours, respectively (table 12), despite the fact that an average of 3.7 more type write-ups were made per section by the type-sampling reconnaissance method. This more efficient use of field time by the type-sampling reconnaissance method, however, was offset by the extra cost of contact prints and of transferring the map data from the prints to the planimetric base.

The type-sampling and the grid procedures of the square-foot-density method both cost more per acre than did the reconnaissance methods. Average per-acre expenditures of 9.88 mills for the grid square-foot-density method and of 11.53 mills for the type-sampling square-foot-density method were required to complete the survey to the same point as discussed for the reconnaissance methods. The type-sampling procedure required 4.86 hours per section for field and camp work compared with 4.60 hours per section for the grid procedure. Undoubtedly the greater time required by the type-sampling procedure results from the increased number of plots taken by that method.

The summary of time required for each activity given in table 12 shows that a large proportion of the reconnaissance method is field work, whereas the square-foot-density method requires that considerable time be

Table 12.--Average time (hours) required to complete the field survey on a section by the four range-survey methods

Grid procedure

Item	I. Reconnaissance Block 1	Block 2	Block 3	Total	II. Square-foot-density Block 1	Block 2	Block 3	Total
Total field time	4.13	3.76	3.59	3.83	4.02	3.57	3.47	3.69
Field mapping	3.60	3.43	3.27	3.43	4.02	3.57	3.47	3.69
Field compilation	.53	.33	.32	.40	--	--	--	--
Total camp time	.35	.24	.26	.28	1.23	.77	.73	.91
Camp mapping	.35	.24	.26	.28	.30	.18	.21	.23
Camp compilation	--	--	--	--	.93	.59	.52	.68
Total field and camp	4.48	4.00	3.85	1/ 4.11	5.25	4.34	4.20	1/ 4.60

Type-sampling procedure

Item	III. Reconnaissance Block 1	Block 2	Block 3	Total	IV. Square-foot-density Block 1	Block 2	Block 3	Total
Total field time	3.27	3.42	3.27	3.33	4.17	3.87	3.50	3.84
Field mapping	2.76	2.93	2.89	2.87	4.17	3.87	3.50	3.84
Field compilation	.51	.49	.38	.46	--	--	--	--
Total camp time	.27	.21	.16	.21	1.16	1.08	.81	1.02
Camp mapping	.27	.21	.16	.21	.25	.20	.14	.20
Camp compilation	--	--	--	--	.91	.88	.67	.82
Total field and camp	3.54	3.63	3.43	1/ 3.54	5.33	4.95	4.31	1/ 4.86

1/ Significance of differences between methods as determined by "t":

I and II, t = 6.152**
I and III, t = 6.935**
I and IV, t = 9.869**
II and III, t = 14.027**
II and IV, t = 3.884**
III and IV, t = 18.260**

** Odds that differences are due to method and not sampling are 99 in 100 or more.

spent in compilation after the field work is complete. By the grid and type-sampling procedures of the reconnaissance method 93 and 94 percent of the time, respectively, was spent in the field compared with 80 and 79 percent when using the square-foot-density method. The time spent summarizing the plant densities estimated on the 100-square-foot plots by the square-foot-density method was considerably greater than that required to compute the forage factors from the type write-ups using the reconnaissance method.

COST OF AERIAL PHOTOGRAPHY

The foregoing data do not include cost of the aerial photography and drafting of the planimetric base maps from the aerial photographs. Aerial photographs and the resultant planimetric base maps have many uses other than providing more adequate control for range surveys and, therefore, often are not included in range-survey costs. These photographic and engineering costs vary somewhat with different projects. For this study the cost was $5.11 per square mile, distributed as follows:

Photography	$2.00 per square mile.
Mapping control	1.25 per square mile.
Drawing planimetric base	1.86 per square mile.
Total	$5.11 per square mile.

A cost of 5.11 dollars per square mile is equivalent to 7.98 mills per acre. Should this be added to range-survey cost the per-acre expenditure for the type-sampling reconnaissance method would be 16.98 mills, and for the type-sampling square-foot-density method 19.51 mills.

From the standpoint of increasing the accuracy of forage estimates obtained by the reconnaissance method, it is doubtful if the added total cost of the aerial photography and the planimetric base map is justified.

The type-sampling procedure made possible by aerial photographs increased the accuracy of the forage estimates only 2.0 percent but raised the survey cost from 9.00 mills per acre to 16.98 mills per acre. For the square-foot-density method, the increased accuracy shown by the type-sampling procedure made possible by using aerial photographs was sufficient to warrant the added total costs. Calculations from the data indicate that to obtain an accuracy by the grid square-foot-density method similar to that obtained by the type-sampling square-foot-density method, the number of plots would need to be doubled. This would increase the per-acre cost of the grid procedure to slightly above the total cost of 19.51 mills needed to finance the flight, aerial photographs, drafting the planimetric base map, and the field survey for the type-sampling procedure. However, compared with the accuracy and cost of the grid reconnaissance method, neither doubling the intensity of the grid square-foot-density method nor financing aerial photography and the planimetric base map in connection with the type-sampling square-foot-density method is justified.

When the procurement of a more accurate type map is considered in addition to the increased accuracy of forage estimates obtained through use of aerial photographs, the added total cost of financing the flight and preparing the planimetric base map may be justified in some instances. If films for the contact prints and the planimetric base map are available without cost, the use of the type-sampling procedure by either method is clearly justified.

SUMMARY AND CONCLUSIONS

Range surveys are designed to obtain basic information that will serve as a foundation for effective management of range lands. To fulfill this purpose adequately, each survey of range land should furnish: (1) A reliable forage estimate; (2) an accurate forage type map; and (3) a complete inventory of important problems involved in proper forage and livestock management together with practical suggestions for their solution.

To determine which of the range-survey methods now considered standard, i.e., reconnaissance and square-foot-density, are most effective in obtaining this information, a field test was made on a typical cattle range in the Blue Mountains of Oregon by a 5-man crew during the summer of 1939. All crew members were experienced in estimating range vegetation by one or both of the methods, although two had not previously worked on range surveys and hence were untrained in drawing forage type maps. One field examiner, only, was familiar with the reconnaissance method as applied on range surveys. The area selected for study was a 16,987-acre tract on the Umatilla National Forest, known as the Starkey Cattle Allotment. Each of the five men surveyed the entire area using both standard methods in conjunction with the grid and type-sampling mapping procedures. The result was 20 independent range surveys from which comparisons could be made.

The study was designed to determine: (1) Which of the four combinations (grid reconnaissance, grid square-foot-density, type-sampling reconnaissance, type-sampling square-foot-density) gives the most dependable forage estimates; (2) what variation in forage estimates may

be expected as the stage of plant development advances or the intensity of herbage utilization increases; (3) if forage type maps made with the grid mapping procedure are as reliable as those derived from aerial photographs; (4) the extent to which field examiners making forage estimates will obtain supplemental range-management data; and (5) the relative costs of the different survey methods.

When using the grid mapping procedure, the field examiners surveyed at maximum intensity as specified in the instructions for standard range surveys, traversing twice through each square mile on parallel lines one-half mile apart. Twenty 100-square-foot plots, which were spaced at 8-chain intervals on the survey line, were estimated per section with the grid square-foot-density method. The forage value of subtypes was estimated within each half section when either the grid reconnaissance or the grid square-foot-density method was used.

The type-sampling procedure, with either survey method, was effected by the use of aerial photographs on which differences in vegetation had been shown by type lines previous to the time that the forage estimate was made. In this manner, each examiner estimated range forage within the same subtype areas, thereby largely removing from the process of forage estimation the factor of personal error in drawing type lines. The field examiners were required to estimate the forage of subtype portions within each half section. In the type-sampling square-foot-density method, the minimum sampling intensity recommended in the standard range-survey instructions was used except for areas of high grazing capacity, such as meadows, where the minimum number of plots was doubled. This intensity resulted in estimating an average of

36 plots per square mile.

When making forage estimates of subtypes certain techniques considered essential to good results from the survey methods were strictly followed. For the reconnaissance method these were: (1) Checking each density estimate against the percent of ground not covered with vegetation; (2) selecting definitely bounded areas considered to be typical of the whole subtype to aid in making the vegetation write-up; and (3) periodically recording the total density and percent composition of the main classes of vegetation as a means of checking average conditions for the whole subtype. Forage estimates on each square-foot-density plot were checked (1) by comparing the sum of the separate density estimates of each species against a single density estimate of all the vegetation and (2) by balancing the vegetation density against the area of bare ground.

In order to obtain the greatest independency of surveys by individuals, no comparisons between maps or forage estimates of the study area were permitted. A 12-day training period immediately preceding the study and biweekly checks of density estimates off the area during the study were held to furnish the crew opportunity to maintain a uniform density concept. To eliminate, so far as possible, the effect on forage estimates as the season progressed of increasing familiarity with the methods, advance in vegetation development, and increase in intensity of forage utilization, the area was divided into three 9-section blocks, each being completely surveyed with the four methods by all individuals before work commenced on the next block. To provide against field examiners' becoming unduly familiar with the forage and

forage types on a block, they were required: (1) To make the two surveys first that used the grid mapping procedure; and (2) to travel in a different cardinal direction on each of the four surveys. To compensate for personal bias in methods, each field examiner was assigned at random the order of methods to use on each block in conjunction with the grid mapping procedure and also in conjunction with the type-sampling procedure.

In addition to making four complete surveys of the area, the field examiners: (1) Maintained records of the time required to complete their surveys by each method in order that relative costs of the different survey methods could be calculated; and (2) estimated forage by the reconnaissance and square-foot-density methods at weekly intervals throughout the study period on two series of plots to determine if uniformity of estimates could be maintained as the vegetation matured and dried and the intensity of utilization increased.

Both the reconnaissance and the square-foot-density methods, using either mapping procedure, proved sufficiently sensitive in their forage measurements to warrant the statement that either may be used effectively to show relative forage values on different parts of a range.

Uniformity in forage estimates is prerequisite to a good range-survey method. Uniformity in this case depends on: (1) The maintenance of similar density concepts by members of the survey crew; (2) the consistency with which the field examiners estimate the forage they encounter; and (3) the degree to which the estimate of forage encountered is representative of the forage on the area being surveyed.

Average differences of less than 13 percent between forage estimates of the five field examiners when using either reconnaissance method, which were significantly smaller than was the case for the square-foot-density methods, give evidence that, with equal training, individuals of a crew maintain a more uniform density concept with the reconnaissance method than with the square-foot-density method.

Estimates of forage encountered made by the examiners when using the grid square-foot-density method, as evidenced by magnitude of the standard errors, were the least consistent of the methods. Estimates of forage encountered were most consistent for the type-sampling reconnaissance method, closely followed by the grid reconnaissance method and the type-sampling square-foot-density method.

Direction of travel affected the consistency of estimates by the reconnaissance methods and failed to do so in the case of the square-foot-density methods, thereby indicating that estimates by the reconnaissance methods of the forage encountered did not always depict conditions truly representative of the entire area whereas the average of forage estimates from a transect of impersonally selected square-foot-density plots was as representative of all the forage on the area as of the forage encountered. However, the freedom of travel inherent to the type-sampling procedure permitted seeing enough vegetation on each subtype so that forage estimates made by the type-sampling reconnaissance method were found not to be significantly less representative than were forage estimates made by the type-sampling square-foot-density method. The grid reconnaissance method ranked slightly lower than the type-sampling square-foot-density method because the estimates made by the

former method were not as representative of all the forage on the area.

The analysis of data on forage estimates made by individual field examiners with the four method combinations indicates: (1) A relatively uniform and consistent spread in forage estimates between examiners is to be expected in any survey method; i.e., some individuals estimate consistently low and others consistently high; (2) with the reconnaissance method, uniformity of estimates between individuals can be increased by emphasizing that the vegetation of subtype portions for which write-ups are made be thoroughly inspected prior to the final forage estimates; and (3) with the square-foot-density method, uniformity of estimates between individuals can be increased by stressing training in density estimation and by increasing the number of plots to obtain a more adequate sample of the forage.

Accuracy of forage estimates by the reconnaissance method on individual subtypes was materially affected only by the amount of forage on the subtype, estimates being least accurate for subtypes with few forage acres. Average deviation of estimates ranged from approximately 11.5 percent on subtypes containing 60 forage acres to 13.5 percent for subtypes containing 3 forage acres.

Accuracy of forage estimates by the square-foot-density method on individual subtypes was affected by the area, the per-acre forage value, and the number of forage acres on the subtype. Estimates were more accurate for dense than for sparse vegetation, more accurate for large than for small areas of moderate to high forage value, and less accurate for large than for small areas of low forage value.

When used in the manner customary in range surveys, each field

examiner making forage estimates of a different part of the range, the type-sampling reconnaissance method gave more dependable results than did the other three methods. Considering differences between estimates of the examiners as well as the uniformity of the method, estimates of forage on a single section by one examiner are expected to be within ±13.05 percent of the average value that would be obtained were the entire crew to estimate the forage. Similar expected variations from uniformity by the grid reconnaissance, the type-sampling square-foot-density, and the grid square-foot-density methods were ±15.02 percent, ±15.85 percent, and ±23.56 percent respectively.

Forage estimates made by the examiners on the same areas at weekly intervals throughout the grazing season and which were affected as the season progressed (1) by the advance in stage of plant development and (2) by the increase in amount of herbage used by livestock, did not vary materially for any period. Mental reconstruction of the vegetation to its ungrazed, fully developed stage, made possible by the experienced observation of the examiners who followed its changes throughout the season, was sufficiently effective to overcome the difficulty of maintaining uniformity of density estimates throughout the season.

Forage type maps when drawn by the grid mapping procedure by different field examiners or when redrawn by the same examiners passing through the section in a different direction differed widely as to the location of boundaries between types and subtypes and as to type and subtype classification. Forage estimates were affected because of the consistent tendency to overestimate the amount of waste range due to

dense timber thickets. Type maps drawn by men with little experience in the grid procedure tended to be generalized and to depict the vegetation on the ground inaccurately. This tendency rapidly was overcome with additional experience.

Drawing the forage type map with the aid of aerial photographs permitted dividing the area into types and subtypes that more closely represented visible changes in the vegetation. The value of the type map thus drawn was increased further because of the greater accuracy with which range improvements and range facilities such as fences, corrals, salt grounds, and stock-watering places could be mapped by referring to streams, trees, roads, and other features plainly depicted on the photographs. The dependability of forage estimates was increased through the assignment of equitable areas to waste and non-waste types and by permitting the examiner greater freedom of travel through each subtype.

Using either mapping procedure, variations in classification of types and subtypes occurred, indicating that these discrepancies, which are not serious to range management, should be expected on forage type maps and should not be held to minimize the dependability of the survey.

Field examiners were relatively ineffective in locating management features when using either the reconnaissance or the square-foot-density method. The most observant examiner found less than half of the springs and less than one-third of the salt grounds on the area. Moreover, the adequacy of the write-ups on specific management problems and suggested solutions prepared individually by the examiners proved to depend more on the character of the examiner than of the survey method.

Costs were less when making range surveys by the reconnaissance method than by the square-foot-density method. The cost of the field work[14/] by the reconnaissance method was 9.00 mills per acre when mapping directly on aerial photographs and 9.09 mills per acre when using the grid procedure. By the square-foot-density method comparable work cost 11.53 mills per acre for the type-sampling procedure compared with 9.88 mills for the grid procedure.

If aerial photography and drafting the planimetric base map are financed by the range-survey project the survey costs are increased by approximately $5.11 per square mile or 7.98 mills per acre.

The conclusions developed from the study as to the use of range-survey methods are:

1. The type-sampling reconnaissance and square-foot-density methods and the grid reconnaissance method, when conducted at similar intensity and with similar care to that used in the study, are justifiable for use in range surveys from the standpoint of uniformly dependable forage estimates.

2. The grid square-foot-density method, conducted at an intensity of 20 plots per section, obtains forage estimates that are so unreliable and at the same time is so expensive that its use in range surveys is not justified.

3. If films of aerial photographs and the completed planimetric base map are available without cost, the type-sampling reconnaissance method is the cheapest and the most accurate of the standard range-survey

14/ Includes completion of the forage type map ready for compilation of the type acreages. (Cost of aerial photography and planimetric base map not included.)

methods and is, therefore, recommended for use where these conditions prevail.

4. If aerial photographs are not available or their cost is prohibitive, the grid reconnaissance method conducted at an intensity of two strips per section is recommended since its dependability is but slightly less than that obtained from either the type-sampling reconnaissance or the type-sampling square-foot-density methods.

5. If, for reasons aside from obtaining dependable estimates of the amount and distribution of range forage, the characteristics of the type-sampling square-foot-density method are held in preference to those of the type-sampling reconnaissance method, its use in range surveys is justifiable since accuracy as acceptable can be obtained at but slightly higher cost.

6. Mental reconstruction of vegetation that has passed the optimum plant-development stage or that has been moderately to heavily grazed is sufficiently effective to maintain uniform forage estimates throughout the season, provided the crew has had the benefit of observing the vegetation throughout the season, and, hence, has retained a mental picture of plants in their undisturbed condition.

7. When using the reconnaissance method, the chief of party should stress the importance of adequate inspection of each subtype to insure representativeness of the forage estimates.

8. When using the square-foot-density method the party chief should lay special emphasis on frequent and intensive comparisons of density estimates by the crew to insure uniformity in forage estimates, and on taking as many plots per subtype as time and cost will permit to obtain the most representative estimates.

9. Examiners can be expected to vary consistently above or below the crew average in their density estimates. Therefore, to provide for the most uniform results the field work should be so arranged that as many crew members as possible survey within each range unit that is considered important from the standpoint of livestock distribution.

10. Regardless of the method used, the forage estimates are but one phase of a range survey. An inventory of the management features, of range problems, and of means for their practicable solution is as important to obtain from the survey as are dependable forage estimates. The field examiners are taxed to the utmost in producing an accurate type map and in obtaining dependable forage estimates. The responsibility for obtaining and interpreting the management inventory is deemed principally to rest with the chief of party who should, therefore, spend considerable effort in this important activity. In order to fulfill this responsibility the chief of party should be thoroughly versed in the field of practical as well as technical range management.

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